MINISTRY OF MINES AND ENERGY

BARRIER REMOVAL TO NAMIBIAN RENEWABLE ENERGY PROGRAMME (NAMREP)

FINAL REPORT

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Code of Practice and Register of Products for Namibian Solar Energy Technologies

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Prepared by:

emCON Consulting Group	Tinda ESI Consultants cc
P O Box 1900 Windhoek Namibia Tel + 264 - 61 – 224 725 Fax + 264 - 61 – 233 207 Email contact@emcongroup.com	P O Box 60681 Katutura Namibia Tel + 264 - 61 – 271 941 Fax + 264 - 61 – 213 377 Email tindaesi@iway.na

Table of Contents

Table of Contents i

Acknowledgements iii

Abbreviations iv

Executive Summary 1

1 Introduction 3

1.1 Operating conditions for SET's in Namibia 4

1.1.1 Namibian Climate 4

1.1.2 Namibian Water Quality 8

1.1.3 Corrosion in Namibia 9

1.1.4 Namibian Conditions Summary 9

2 Register of Recommended Products 10

2.1 Criteria for product assessment 10

2.1.1 Solar Home Systems 10

2.1.2 Photovoltaic Water Pumps 13

2.1.3 Solar Water Heaters 15

2.2 Evaluation of Namibian products 16

2.3 Register of Approved Namibian SET products 17

2.4 Maintaining the Approved Products Register 19

3 Code of Practice 21

3.1 Code of Practice for Solar Home Systems 21

3.1.1 Components of a Solar Home System 22

3.1.2 Safety guidelines 22

3.1.3 Site assessment 23

3.1.4 Installation 25

3.1.5 Commissioning 34

3.1.6 Hand-over to customer 34

3.1.7 Maintenance 35

3.2 Code of Practice for Photovoltaic Water Pumps 36

3.2.1 Components of a PVP 36

3.2.2 Water heads and delivery explained 38

3.2.3 Safety guidelines 39

3.2.4 Preparation of the system 39

3.2.5 Site assessment 45

3.2.6 Installation 47

3.2.7 Commissioning 51

3.2.8 Hand-over to customer 51

3.2.9 Maintenance 52

3.3 Code of Practice for Domestic Solar Water Heaters 53

3.3.1 Components of a Solar Water Heater 53
3.3.2 Safety guidelines 55
3.3.3 Site Assessment 55
3.3.4 Installation 59
3.3.5 Commissioning 62
3.3.6 Hand-over to customer 62
3.3.7 Maintenance 63
4 Recommendations 64
5 References 65
Annexure 66
A1 Evaluation of SHS Components 66
A2 Evaluation of Photovoltaic Pumping Products 68
A3 Evaluation of Solar Water Heater Products 69
A4 Stakeholders 70
A5 Workshop proceedings 73
A6 Terms of Reference 78

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The Codes of Practice were compiled and authored by:

Solar Home System

Axel Scholle

Dr Detlof von Oertzen

Photovoltaic Water Pumping

Werner Schultz

Robert Schultz

Axel Scholle

Dr Detlof von Oertzen

Solar Water Heaters

Alastair Gets

Glenn Howard

Axel Scholle

Udo Kutz

Dr Detlof von Oertzen

Abbreviations

a-Si	Amorphous Silicon
BCEW	Bare Copper Earth Wire
CdTe	Cadmium-Telluride
CFL	Compact Fluorescent Lamp
CIS	Copper-Indium-Diselenide
DB	Distribution Board
DOD	Depth of Discharge
ELU	Earth Leakage Unit
HDPE	High Density Polyethylene
IEC	International Electrotechnical Commission
IV	Current Voltage curve (characteristic of module)
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MME	Ministry of Mines and Energy
MOV	Metal Oxide Varistor
NAMREP	Namibia Renewable Energy Programme
ppm	parts per million
PV	Photovoltaic
PVP	Photovoltaic Water Pumping
RE	Renewable Energy
REEE	Renewable Energy and Energy Efficiency
SABS	South African Bureau of Standards
SANS	South African National Standard
SET	Solar Energy Technologies (In this study: SHS, PVP & SWH)
SHS	Solar Home System
SOC	State of Charge
SRF	Solar Revolving Fund
SWH	Solar Water Heater
TDS	Total Dissolved Salts
UL	United Laboratories
UNDP	United Nations Development Programme

Executive Summary

The Namibia Renewable Energy Programme (NAMREP) has commissioned a consultancy for the establishment of a Register of Recommended Products and for the drafting/adoption of Codes of Practice. Both tasks address three Solar Energy Technology (SET) areas, being Solar Home Systems (SHS), Solar PV Water Pumping Systems (PVP) and Solar Water Heaters (SWH).

The NAMREP programme has identified as part of its overall barrier removal activities that the solar energy products on the Namibian market require minimum quality levels to increase the reliability of Solar Energy Technologies particularly in government supported programmes. Furthermore, investigations over the last four years have shown deterioration in the quality of the workmanship with regards to the installation of Solar Home Systems. Since the Solar Revolving Fund now offers loans for SHS, PVP and SWHs it was appropriate to compile Namibian Codes of Practice for these Solar Energy Technologies.

Register of Products

The main components that are being evaluated in the Register of Products are:

Solar Home Systems:

- PV modules, Batteries, Charge controllers, Lamps and Inverters

PV Water Pumps:

- PV modules, Electronic controllers and motor/pump subset

Solar Water Heaters

- Collector and Storage Tanks

The criteria for the evaluation of product have been compiled by taking account of the following:

- Namibian climatic conditions
- Quality & Reliability aspects
- Life expectancy

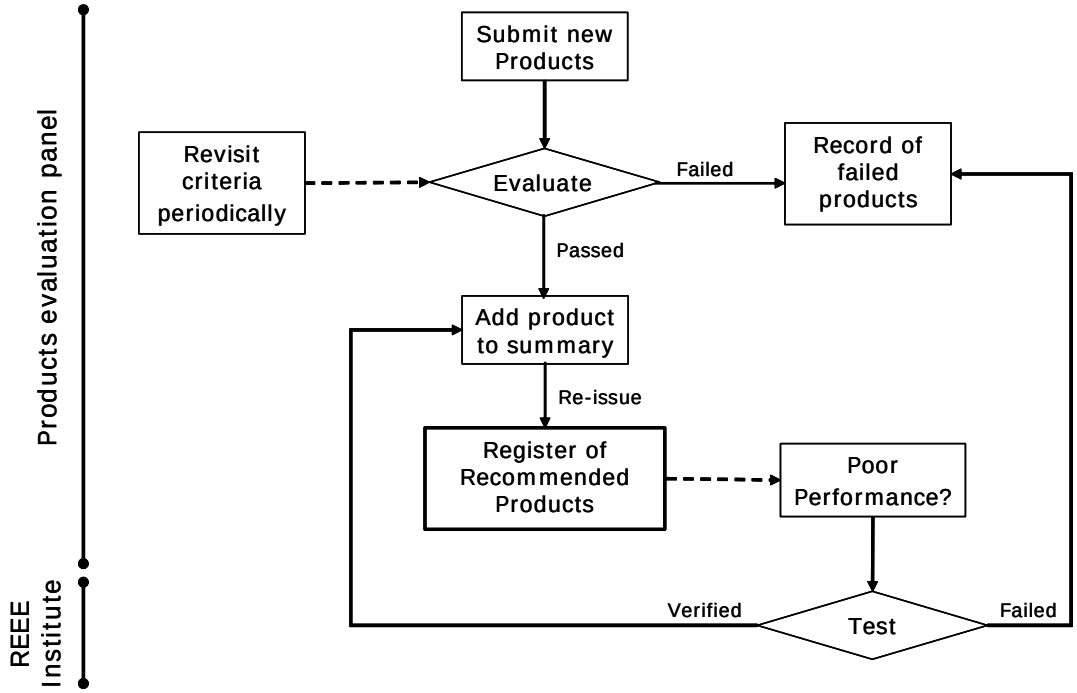
Care was taken to select criteria that avoid being over-prescriptive while still being in the interest of the customer. Criteria were therefore selected to be practical (for example: No criteria were stated by require a long term test of the component – Namibia currently does not have the funds, the capacity and possibly the equipment to run such tests), verifiable (i.e. the information requested is mostly available) and realistic.

The criteria were presented and discussed at a workshop where criticism and recommendations were incorporated

The administration of the Register of Recommended Products will initially lie with NAMREP. The evaluation document (Excel spreadsheet) currently holds the majority of Namibian products on record and has evaluated those products. A summary of the recommended products has been issued (Version May 2006 Rev 0). The procedure for updating and maintaining the Register is shown in the Figure below. It involves the following steps:

- Formation of a products assessment panel around NAMREP (as administrator of register).
- The panel evaluates products that are submitted by a party.
- The submitted product information needs to address to set criteria.

- Products are added to the register if passed. If the product fails then it is retained on record.
- The updated product registers is circulated tri-monthly with a new version number to loan institutions, solar technicians and suppliers.
- The criteria are revisited in view of developments in the sector or if certain criteria are found to be ineffective or counter-productive.
- Products that under-perform (post-approval) and do not life up to their specifications are tested at a local institution or with involvement of the private sector, if feasible (e.g. the life expectancy of a compact fluorescent lamp).



Codes of Practice

The compiled Codes of Practice address all the activities around the site of installation and are regarded as a practical field guide, which is hand-on and accessible. The beneficiaries of the Codes are the solar technicians.

A number of Codes of Practice and documents were reviewed. Information that was taken from existing Codes was referenced in the Namibian Codes of Practice.

The Codes of Practice include the following topics:

- Safety guidelines
- Site assessment
- Installation
- Commissioning
- Maintenance
- Hand over to customer

1 INTRODUCTION

Solar Energy Technologies (SET) have been employed in Namibia since the early '70. At that stage the usage of solar PV modules to power Telecom microwave stations was ideal due to the remoteness of some of these repeater stations. During the '80's the first large scale solar PV pumps were installed in remote areas and the first attempts at solar water heating through using a collector and a hot water tank were instigated. None of the introductions were unproblematic and that was due to a myriad of factors - from technology, to harsh operating conditions, to poor understanding of capabilities, to maintenance, to social issues (poverty and theft). What could also be observed were the fluctuations in the quality of products. Solar PV water pumping had just made its in-roads into the market when a fairly poor quality and untested product would enter the market to undo the positive reputation gained.

The purpose of this work is to reduce the incidences of poor quality products and of poor workmanship by setting minimum requirements for the quality level of products and by providing guidelines to installers of Solar Home Systems (SHS), solar PV water Pumps (PVP) and Solar Water Heaters (SWH).

The content of this report includes:

- The prevailing climatic conditions in Namibia to define a range of operating conditions for SET products.
- The definition of a set of criteria for each of the main components found in Solar Home Systems, solar PV water Pumps and Solar Water Heaters as well as an evaluation of the current products on the market to result in a Register of Recommended Products for use under Namibian conditions.
- The drafting/adoption of a Code of Practice for the installation, commissioning and maintenance of SHS, PVP and SWH. The Codes are targeted at the solar technicians of Namibia with the aim of providing a practical field guide listing the essential issues that require attention during installation and follow-up maintenance.

The consulting Team made use of available standards for SET's to define the criteria for product selection. In consultation with most importers and manufacturers of SET's (refer to Annexure A4) the Team compiled a list of products currently found on the Namibian market. These were evaluated according to the criteria and summarised in a Register of Recommended Products. The findings were presented in a workshop and discussed among the stakeholders. This report includes the recommendation and criticisms received during the workshop.

The Codes of Practice were compiled and adopted from various sources that have all been referenced. The main focal areas of the Codes were presented and discussed at the workshop. The Team made use of the experienced private sector technicians to assist in the drafting of the Codes of Practice.

1.1 OPERATING CONDITIONS FOR SET'S IN NAMIBIA

In order to analyse and recommend solar energy components/systems that are suitable for operating under Namibian conditions, the prevailing climate and environmental conditions in Namibia need to be described.

1.1.1 Namibian Climate

An excerpt from a submission to the World Meteorological Organisation provides a good description of Namibia's climate:

> "*Namibia's climate is predominantly semi-arid to arid, with large areas to the east and west being occupied by Kalahari Desert and Namib Desert respectively. The northern and north-eastern margins of the country are affected by sub-humid tropical climate regimes.*
>
> *The main rainy season occurs during southern hemisphere summer in the months of October to April. However, winter rainfall is not an uncommon feature in the extreme southern parts of the country where it accounts for over 50% of annual rainfall in some places. Average annual rainfall is highly variable in both time and space. In terms of time, the largest year-to-year differences are in the lower rainfall areas in the western and southern parts of the country where the coefficient of variation generally exceeds 1.00 (or over 100% variability). In the north and northeast, where annual rainfall is relatively much higher, the coefficient of variation is just about 0.20 (or 20% variability). In terms of space, mean annual rainfall varies from under 20mm along the coast, to around 700mm in the extreme north-eastern parts of the country.*
>
> *On average, summer day-time temperatures are warm to hot, and generally range from about 20°C to just under 40°C, while average winter night temperatures range from about 5°C to about 10°C. The coastal areas exhibit the smallest temperature ranges, a moderation partly due to the cool south-westerly winds over the Benguela current in the Atlantic ocean. Over much of the central areas which include Windhoek, the capital city, conditions are fairly pleasant due to the moderating effect of the high altitude*".[1]

The extent of the climatic conditions over the whole of the country are well illustrated by the charts produced by the ACACIA project at the University of Cologne using data from the Atlas of Namibia[2].

As far as SET's are concerned solar radiation is the most important with possibly hours of sunshine following close behind. These are presented below in Figure 1.1 and Figure 1.2. It is interesting to note, for example, that Mariental has an average radiation of between 6.0 and 6.2 kWh per m^2 per day as well as an average of more than 10 hours of sunshine per day.

[1] Source: A text submitted by "Namibia" to the World Meteorological Organisation, 3 to 7 October 2005.

[2] Atlas of Namibia, A Portrait of the Land and its People, Mendelsohn. J, Jarvis. A, Robert. C and Robertson. T, Ministry of Environment and Tourism, 2002.

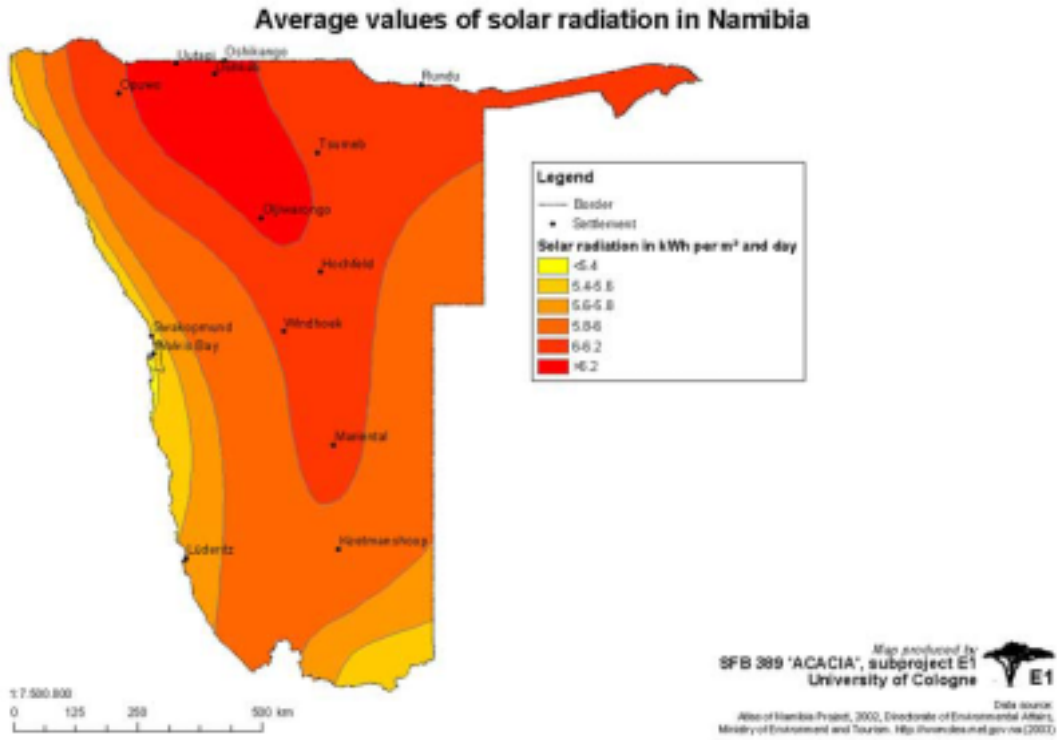


Figure 1.1: Solar radiation in Namibia

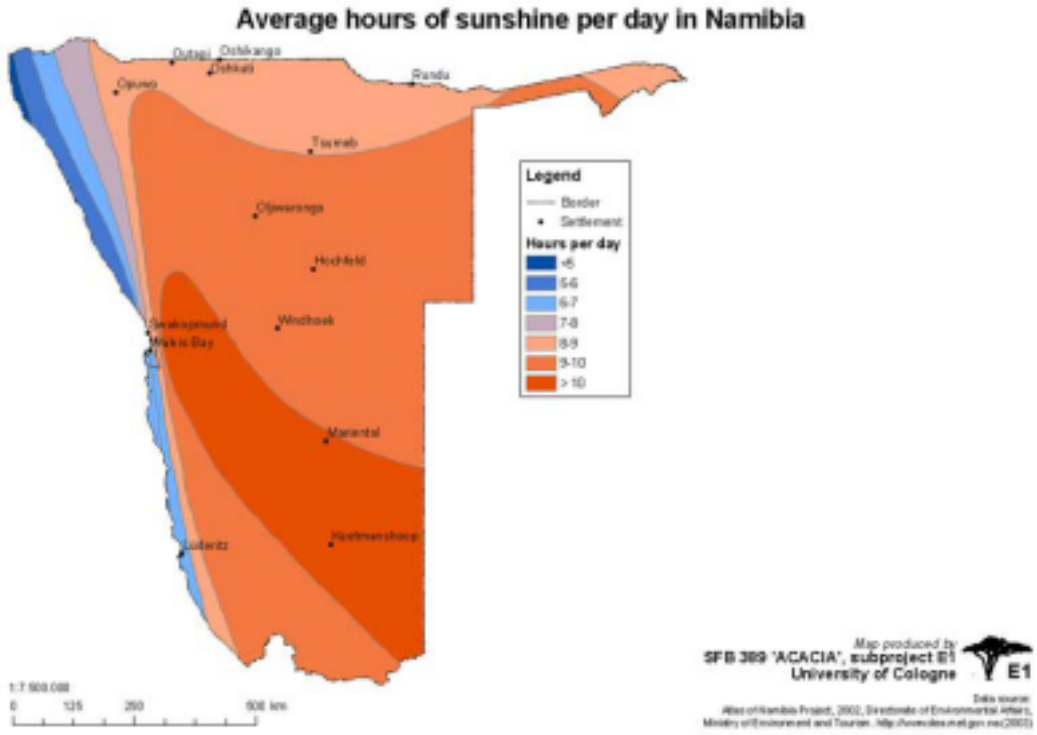


Figure 1.2: Hours of sunshine

In all of Namibia there is an average of more than 300 days of sunshine per year[3]. The midsummer temperatures can rise to 40°C[4] but generally in the hottest summer months (January and February) the temperatures vary between 9°C and 30°C[5]. At night in winter (May to September) the minimum temperatures can be as low as -6°C in the high altitudes but are generally around 6°C and the maximum temperature is around 20°C[6]. The minimum maximum annual temperature variation in central Namibia is illustrated in Figure 1.3 below.

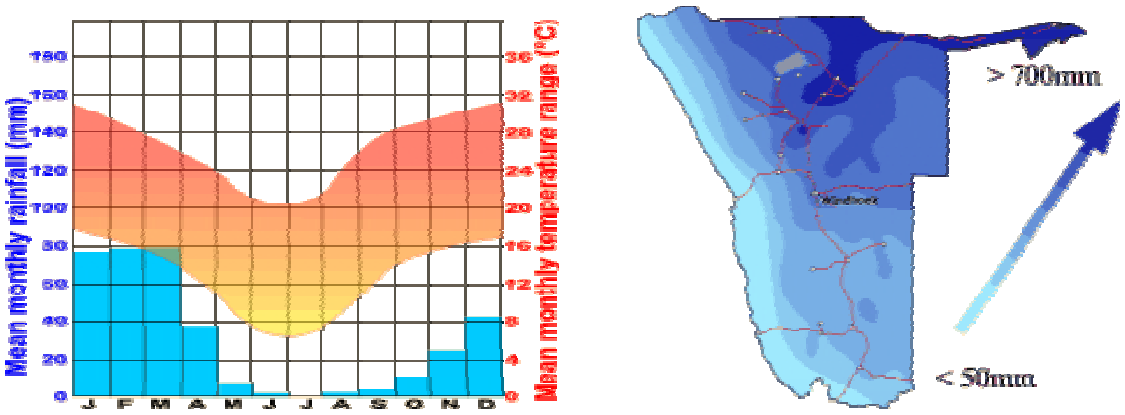


Figure 1.3: Climate Chart for Central Namibia and Namibia rainfall

Source: ***http://www.economist.com.na/facts/facts.htm***

The mean monthly rainfall in central Namibia is shown in Figure 1.3 above and varies from 0 mm in July to 80 mm in March. Rainfall in Namibia is less than 50 mm in the south-west and coast and increasing to more than 700 mm in the north-east and interior as shown in Figure 1.3 above.

[3] http://www.economist.com.na/facts/facts.htm

[4] ibid

[5] http://www.grnnet.gov.na/Nav_frames/Nutshell_launch.htm

[6] http://www.atlapedia.com/online/countries/namibia.htm

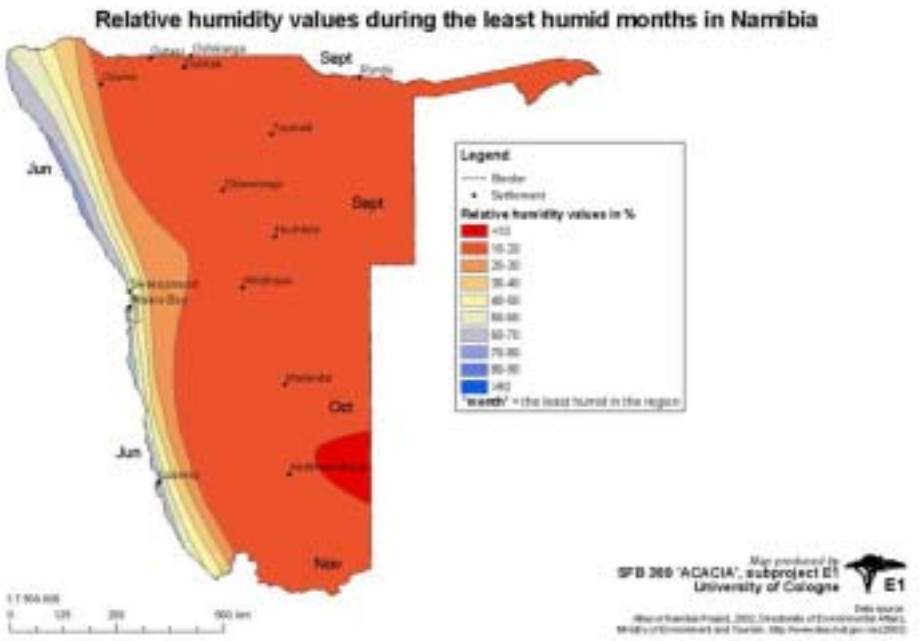


Figure 1.4: Relative humidity during least humid month

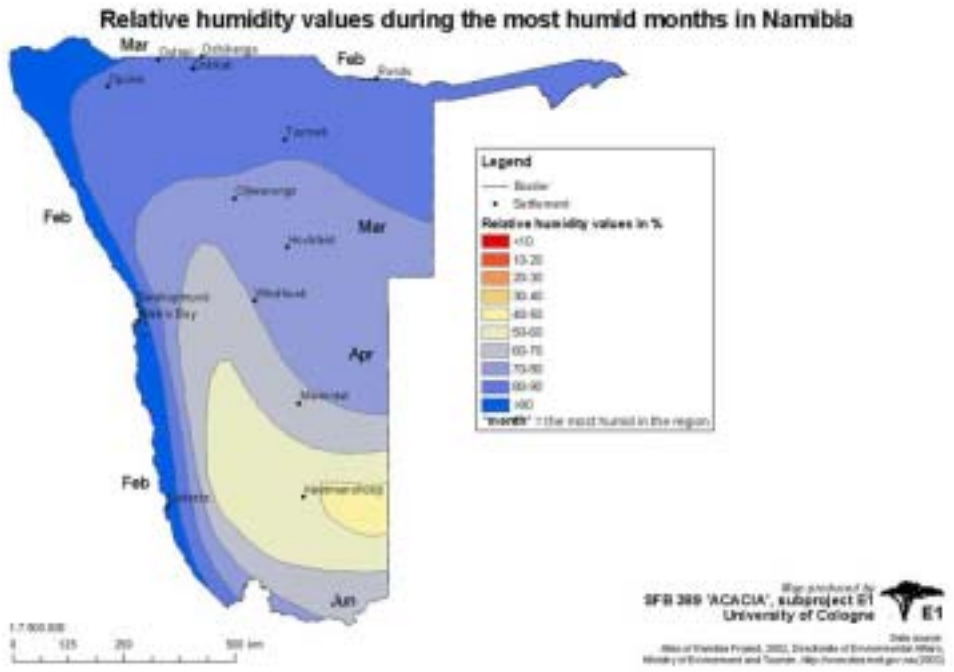


Figure 1.5: Relative humidity during most humid month

Humidity in the least humid months varies from less than 10% in the southeast to 80% on the coast and in the most humid months from 40% in the southeast to more than 90% on the coast. This is shown in Figure 1.4 and Figure 1.5 above.

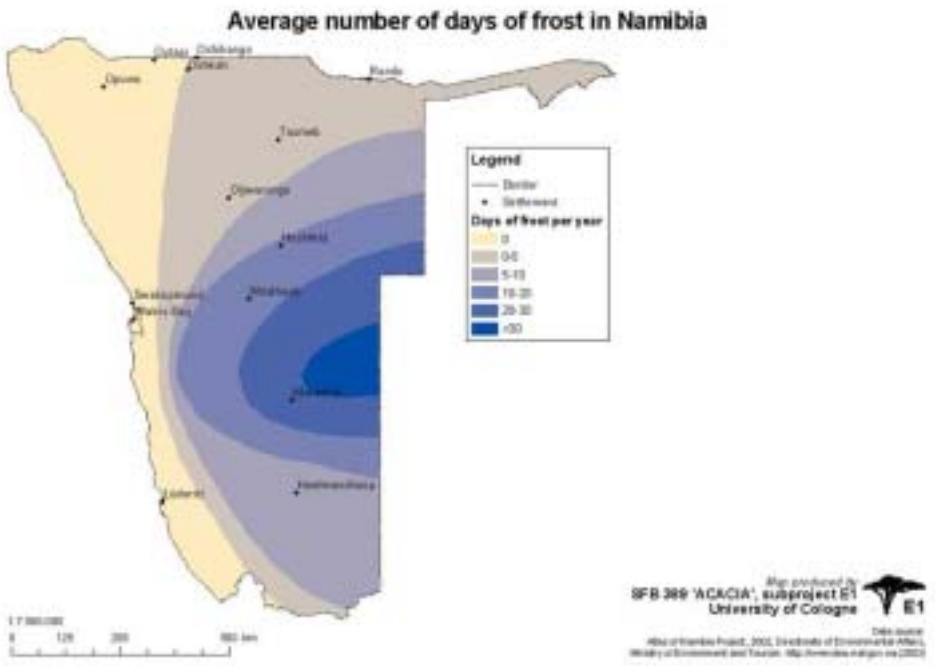


Figure 1.6: Days of frost in Namibia

The number of frost days per year varies from 0 on the coast to more than 30 days on the central eastern border as shown in Figure 1.6 above.

Hail is occasionally experienced in Namibia with hailstones varying in size (no records could be sourced with regards to the hail stone size).

1.1.2 Namibian Water Quality

In a country that has little surface water, most water used in Namibia comes from aquifers. The quality of this water can be gauged by the reading of total dissolved solids (TDS). Potable water has a TDS of up to 2000 mg/l, while the range from 2000 mg/l to 5000 mg/l can be used for livestock, and greater than 5000 mg/l is unusable[7].

Most of Namibia lies on some stored groundwater. Of this:

- most is potable with TDS of <2000 mg/l,
- a small percentages of areas have groundwater with a TDS of >2000 mg/l, and
- a very small percentage of areas have groundwater with a TDS of >5000 mg/l

The quality of the groundwater is variable over the country. However, there is a concentration of areas with groundwater with a TDS of >2000 mg/l and even >5000 mg/l in the southeast of Namibia. This is probably due to the deterioration of the water as it flows from the aquifer from the northeast of the Stampriet area[8].

[7] Atlas of Namibia, A Portrait of the Land and its People, Mendelsohn. J, Jarvis. A, Robert. C and Robertson. T, Ministry of Environment and Tourism, 2002.

[8] Atlas of Namibia, A Portrait of the Land and its People, Mendelsohn. J, Jarvis. A, Robert. C and Robertson. T, Ministry of Environment and Tourism, 2002

1.1.3 Corrosion in Namibia

Little public domain information is available on corrosion indicators of both water and atmospheric corrosion in Namibia. It is however obvious that the coastal regions would have the greatest atmospheric corrosion where corrosion resistant materials are advisable. These will be of less importance as one progresses further inland.

1.1.4 Namibian Conditions Summary

In summary the conditions in Namibia with regard to the Solar Energy Technologies are presented in Table 1.1.

Table 1.1: Summary of Namibian Conditions

	Unit	Min	Max	Notes
Irradiance	W/m^2	0	1,250	1,000 W/m^2 is common at noon on a tilted surface
	$kWh/m^2/day$	4.6[9]	7.8	The average in most of the country exceeds 5.8 $kWh/m^2/day$
Sunlight	h/day	<5	>10	A large area of the country has > 9 h/day of sunlight
Temperature	°C	-6*	40	Maximum change during 24 h is up to 25°C
Humidity	%	<10	>90	In the least humid months most of the country is <20 %
Precipitation	mm	0	>700	Only the far north-eastern part gets >700 mm
Frost	days	0	>10	About 30% of the country has >10 days frost
Lightning strikes	$strikes/km^2/y$	0	10	Mostly inland
Water quality: TDS	mg/l	>1000	>5000	Mostly >1000 with localised areas of 1000 – 5000 mg/l

* Negative temperatures only in the high altitude areas of Namibia.

The criteria for the Register of Recommended Products and the Codes of Practice are guided by the above operating conditions to select suitable products for Namibia and to provide practical installation guidance for SHS, PVP and SWHs.

[9] A solar Radiation Data Handbook for Southern Africa, Anton A Eberhard, 1990

2 REGISTER OF RECOMMENDED PRODUCTS

The purpose of the register of recommended products is to set a minimum standard for products to be used initially for the Solar Energy Systems purchased through the Solar Revolving Fund facility. This step is considered important as a protection of the benefactor as well as strengthening the SET market through improving the reputation of the programme.

2.1 CRITERIA FOR PRODUCT ASSESSMENT

The criteria for the assessment of the products suitability under Namibian conditions are considering mainly quality, reliability and life expectancy beyond the client's payback period issues. Performance criteria are dependant on the design and will differ from case to case. The criteria listed in this section have been drafted with the consideration that the criteria are practical, verifiable and realistic.

The product criteria focus on the mandatory requirements that the products shall meet. In some instances however selected product requirements have been stated as voluntary as these particular requirements are not critical and in order to avoid restrictive trade conditions in the market.

The Team is of the opinion that it will not benefit the solar programme to narrow down the product criteria excessively by becoming over-prescriptive or to expect unrealistic test data on products. That would merely lead to the Register of Recommended Products to become non-implementable and to create barriers to the dissemination of SET's.

2.1.1 Solar Home Systems

The standard Solar Home System consists of solar PV array, a battery, a charge controller and DC lights. In some instances an inverter is part of the system and is used for powering a television, HiFi etc. The technical criteria for component selection of systems financed through the Namibian Solar Revolving Fund are developed here.

2.1.1.1 Photovoltaic module

The photovoltaic module converts solar irradiation into an electric current. There are currently six mainstream PV module technologies available. These are the mono crystalline, poly crystalline, string ribbon silicon as well as the thin-film technologies, amorphous silicon (a-Si), Copper-Indium-Diselenide (CIS) and Cadmium-Telluride (CdTe). The crystalline technology is the oldest and most well established technology. The PV module is usually the largest cost contributor to the initial cost of a Solar Home System.

a) PV module warranty for modules above $15W_{peak}$: 20 years minimum. It is common today that PV module manufacturers provide a 20-year warranty on the PV module, which states that after 20 years this module will still provide 80% of its nominal output. Although there may be many questions around how this warranty can be enforced after such a long period (testing the module, manufacturer still in business, company sold but without the warranty obligations) and how the warranty will be honoured (replacement of module or provision of additional PV module capacity being equivalent to the portion between the measured value and 80% of the nominal value).

b) PV module warranty for modules below $15W_{peak}$: 10 years minimum.

c) Crystalline modules shall comply with IEC 61215, “Crystalline Silicon Terrestrial Photovoltaic Modules; Design Qualification and Type Approval”. Amorphous thin film modules shall comply with IEC 61464, “Thin-film Silicon Terrestrial Photovoltaic Modules; Design Qualification and Type Approval”

d) The PV modules shall be United Laboratories (UL) or ISPRA certified. Alternatively the PV module shall be certified through a different internationally recognised certification body. Note that compliance with IEC 61215 & 61464 means that the PV module is certified.

e) The minimum number of cells in series for crystalline silicon modules shall be 36 cells in order to ensure that the charging current does not decrease significantly as the battery reaches it absorption voltage. A 36 cell module ensures that the charging current near 14.5V does not “slip down the knee” of the IV curve.

f) The modules shall be framed with an aluminium frame.

2.1.1.2 Batteries

The electrolytic energy storage device, the rechargeable battery, forms the heart of the Solar Home System. The battery presents the highest replacement cost item in a Solar Home System, as it has to be replaced a number of times during a twenty-year period. A balance therefore has to be struck between the quality of the battery and its cost in order to minimise the life cycle cost of the battery.

a) The rechargeable battery(ies) shall be lead-acid or lead/calcium-acid batteries.

b) Voluntary: Conventional gel-type batteries are not recommended for Namibian climate conditions as the climate and often the operating conditions within Namibian homes are too hot for the battery and therefore reduce the life expectancy.

c) The battery shall be suitable for cycling applications. Conventional automotive batteries are not acceptable.

d) Battery cycle life at 10% daily depth-of-discharge (DOD) must exceed 1,000 cycles.

e) The rated amphour capacity is specified at 25°C at the C20 (20 hour) discharge rate down to 1.75V per cell (VPC).

f) Batteries shall be engraved with their date of sale and a supplier code.

g) The warranty period of the batteries shall be at least one year.

2.1.1.3 Charge controller

The function of the charge controller is the protection of the battery set, preventing overcharge while providing appropriate charging patterns and protecting against exhaustive discharge.

Charge controllers are mostly based on solid-state technology these days. The charge regulation method is commonly shunt (short-circuiting the PV module) or series (open circuit between the PV module and the battery) regulated. Initial investigations have shown that the long-term effect of shunting solar PV modules has a negative effect on the modules performance and therefore it is not surprising to see that the large manufacturer of charge controllers are moving towards series regulation again.

a) The nominal voltage of the charge controller is 12VDC.

b) The charge controller architecture shall be based on solid-state switching elements.

c) The charge controller shall control the charging process and DC load discharging process.

d) The charge controller algorithm shall incorporate as a minimum a boost (absorption) phase and a float phase.

e) Temperature compensation is required and must be in the range of –3 to -5 mV/K/cell.

f) The charge controller self-consumption shall be below 10mA.

g) The charge controller shall be electronically protected against over-current on the PV input (Namibia experiences short terms irradiances of up to 1300W/m^2) and on the load output. An over-current situation shall therefore not destroy the controller fuse, if present.

h) The charge controller shall as a minimum have the following LED indicators: Charging, Full, Battery Low/Load disconnect. Alternatively the unit shall make use of an LCD.

i) Lightning surge protection must be provided on the charge controller input using an appropriately rated MOV (or other suitable device) between the positive and negative PV input.

j) The charge controller warranty period shall be a minimum of one year.

2.1.1.4 Lamps

Recent development in DC fluorescent lamps has improved the reliability and life expectancy of lamps considerably. Furthermore, the development of LED lamps has made significant advances, making these lamps an interesting option for certain SHS applications such as orientation lighting as well as outside area illumination. An important difference between the fluorescent lamp and the LED lamp is that the LED lamp has a much longer life expectancy (100,000 hours versus 6,000 to 12,000 hours) meaning that the LED lamp will not need replacement during the lifetime of the SHS. In terms of efficiency, a CFL generates about 40 to 60 lumen per Watt with and produces a broader light spectrum while an LED lamp generates about 20 lumen per watt with a very narrow light spectrum.

a) The lamps shall be either compact fluorescent lamps (CFL, with an integrated ballast) or LED lamps.

b) The lamps shall be 12 VDC or 230VAC.

c) The lumens output shall be a minimum of 45 lumen per Watt.

d) The minimum DC operating voltage of the lamp will be 11VDC while the maximum voltage under which the lamp has to operate will be 15VDC. The lamp shall be able to start with a 10V supply voltage.

e) The minimum expected lifetime of the lamp shall exceed 3,000 operating hours.

f) The minimum expected switching cycles of a CFL shall be 40,000.

g) The CFL lamp shall be able to operate in an ambient temperature environment reaching 50°C.

h) Voluntary: The price of a CFL should be proportional to its expected service life. For example, a CFL with a service life of 2,000 hours should cost about a third of a CFL with a service life of 6,000 hours

i) Each lamp must be protected with a fuse rated lower and responding faster than the charge controller fuse.

j) The lamp shall be protected against reverse polarity.

k) Since the lamps life expectancy is related to the number of switching cycles as well as the number of operating hours, it does not make sense to specify a minimum warranty time for the lamp other then specifying the number of operating hours, which has been done above.

2.1.1.5 Inverters

The inverter provides 230VAC output for operating standard appliances such as video machines, large HiFi's etc. Inverter quality aspects are important with regards to power consumption, output waveform and protection.

a) The inverter shall generate a true sine wave with an output voltage of 230V and a frequency of 50Hz +/- 0.5%.

b) The inverter shall provide surge power that exceeds the nominal output by at least 50%. This is particularly important during the switch-on instance of a television or a refrigerator.

c) The inverter no-load power consumption shall be below 1.5% of the nominal output power.

d) The inverter shall have electronic overload and electronic short-circuit protection. Fuse elements on the output are considered poor design, as these elements may be replaced with the incorrect rating and thus lead to damage of the inverter.

e) The inverter must be internally fused at the input of the unit. A DC input circuit breaker is preferred.

f) The inverter must have a low-voltage shutdown threshold, which is no lower than 10.5V at 50% load.

g) The inverter warranty period shall be a minimum of one year.

2.1.2 Photovoltaic Water Pumps

PV water pumps have been playing a significant role in the provision of water in off-grid areas for over 25 years now. The technology has developed around many different designs and in some PVP's the reliability and maintenance requirements have improved significantly over the years. The different technologies have different benefits and therefore need to be evaluated for different applications. Issues that have to be evaluated are ranging from cost, reliability, efficiency, pumping depth, installation, simplicity, to maintenance and component replacement cost and interval. It needs to be kept in mind that neither of these issues are criteria that can be used to approve/disqualify a product for use in the Solar Revolving Fund. The criteria for approving a PVP will have to be based on quality issues.

In terms of service intervals it needs to be clear that depending on the components and pumping technology employed the service interval will be for example every year for the replacement of DC brushes or the replacement of diaphragms or every five years for the replacement of stator in a helical rotor pump. This information needs to be provided to the end user so that an informed decision can be taken.

There are currently three pumping configurations commonly utilised in Namibia:

1) DC drives with surface mounted electronic controller. This consists of five pump technologies:
    a. Positive displacement: Diaphragm pump: Submersible motor/pump (Example: Shurflo, DivWatt, All Power).
    b. Positive displacement: Helical rotor pump: Brushless DC motor: Submersible motor/pump (Example: Lorentz HR range).
    c. Centrifugal: Submersible motor/pump: Brushless DC motor: (Example: Lorentz C range).
    d. Positive displacement: Helical rotor pump: Brushed DC motor: Surface mounted motor, shaft-driven pump. (Example: Mono/Orbit pump with DC motor)
    e. Positive displacement: Piston pump: Surface mounted motor, shaft-driven pump. (Example: Juwa)
2) AC drives with surface mounted electronic controller. This category consists of one technology, being a centrifugal pump with a submersible motor/pump set (Example: Grundfos SA 1500 and SA 400 which has been utilised extensively in Namibia but is now no longer manufactured). Another pumping configuration is a positive displacement pump using a helical rotor pump with a surface mounted induction motor and a shaft-driven pump. (Example: Mono/Orbit pump with three-phase AC motor). This configuration is however not common and currently only exists as a proto-type.
3) Pump drives with submersible electronic controller:
    a. Positive displacement: Helical rotor pump. (Example: Grundfos SQ Flex).
    b. Centrifugal. (Example: Grundfos SQ Flex).

2.1.2.1 Photovoltaic modules

The requirements for the PV modules in a PV water pumping systems are the same as for Solar Home Systems; refer to section 2.1.1.1 Photovoltaic module, with the exclusion that the modules used in a PVP do not need to meet the requirement of 36 cells per module. A PVP usually operates at higher voltages (occasionally at 12V, but mostly at 24V and higher). The choice of PV module is therefore guided by specific design criteria.

2.1.2.2 Pumping Subsystem

The pumping subsystem converts electrical DC power into hydraulic power, capable of lifting water out of the borehole/river into a storage system. The requirements for PVP are:

a) The warranty of the pump subset and the electronic controllers shall be a minimum of one year.

b) The electronic controller shall be overload protected and short-circuit protected.

c) PVP systems based on centrifugal pumps shall be dry-run protected.

d) Voluntary: The electronic controller will indicate the fault status on its display to assist the user with a problem analysis.

e) All exposed power electronic equipment shall be housed in an IP65 rated enclosures.

f) The submersible part of the pumping system must be constructed of corrosion-resistant materials such as stainless steel, bronze alloy or PVC.

g) The PVP shall provide clear specification of the service intervals.

h) A new PVP model shall produce a verifiable track record as to avoid the Namibian market supported by the revolving fund to be used as a test site.

2.1.3 Solar Water Heaters

Recent studies have shown that Solar Water Heaters are due to have a larger impact on the market in the future due to electricity price increases and due to the real term price decreases of Solar Water Heaters. This has lead to a reduction in the years to break even, making the SWH option more attractive based on a 15 years life expectancy.

2.1.3.1 General System Type and performance

a) The Solar Water Heaters shall be of the closed circuit/indirect type, using heat exchange to a potable water storage tank. No potable water shall be circulated directly through the collectors (i.e. no indirect systems).

b) In a close-coupled system, heating shall operate under a natural thermosiphon principle.

c) The SWH system shall be able to deliver hot water using solar radiation energy alone, its full rated storage tank capacity of hot water from 20°C to at least 55°C during a nominal sunshine day (1,000 W/m^2) at any location in Namibia.

d) Solar water heaters shall carry a warranty against manufacturing defects, faulty material / workmanship and leakage from corrosion for a minimum of five years, if installed according to manufacturer's instructions.

2.1.3.2 Solar collectors

a) The solar collectors shall have a minimum tempered glass cover thickness of 3mm.

b) The collector casing shall be manufactured from mild steel or aluminium.

c) The collector panels shall be insulated at the back and sides with at least 50 mm insulation material.

d) The absorber plates shall comprise of aluminium, copper or steel, and shall be provided with some form of heat absorbing coating.

e) Each collector shall be pressure tested to a minimum of 425 kPa and shall be protected against over-pressure

2.1.3.3 Storage Tank

a) The storage tank pressure vessel shall withstand hydraulic testing to at least 2,000 kPa. The tank shall be protected against over-pressure.

b) An outer casing surrounding the insulation of mild steel or aluminium shall be wrapped tight around the insulation material surrounding the steel tank. Aluminium casings shall be preferred, particularly for use in coastal areas.

If mild steel is used for the outer casing, it shall be surface treated to have a high resistance to corrosion, such as galvanising or powder coating.

c) The storage tank shall be insulated as follows:

   i. The insulation shall be of suitable approved material, such as high-density polyurethane and shall also be environmentally friendly (CFC FREE).

   ii. The insulation material shall have a low thermal conductivity. The total thickness of the insulation material shall be such that the resistance achieved shall be at least 0.40 W/m²°C.

d) The guarantee shall allow the Solar Water Heaters to be suitable for use with water with a TDS (Total Dissolved Solids) content of up to 1000 ppm and for which the total hardness does not exceed 200 ppm CaCO3.

e) For steel tanks, a replaceable sacrificial magnesium anode shall be fitted inside the storage tank to protect the steel tank against corrosion.

f) Voluntary: Solar water heaters should be equipped with a supplementary electrical booster element.

   i. The electrical boosting element(s) shall be of the immersion type, copper sheath, rated for 230V standard voltage.

   ii. A combination thermostat / safety cutout shall be installed to control the electrical booster heating element to the required pre-set temperature.

   iii. The safety cutout shall de-energize the element should the temperature within the tank reach 67°C when the element is activated.

   iv. The safety cutout shall automatically reset when the temperature falls back below 67°C (there should be no hysteresis).

2.2 EVALUATION OF NAMIBIAN PRODUCTS

The products traded in Namibia for the various Solar Energy Technologies have been evaluated in a spreadsheet. The spreadsheet lists all the products that have been submitted for registration as well as all the current criteria for products as listed in section 2.1 above. Each product is evaluated against these criteria and either passes or fails. The evaluation is attached in the Annexure, in sections 0, A2 and A3.

2.3 REGISTER OF APPROVED NAMIBIAN SET PRODUCTS

The evaluation of the products is summarised to reflect all the products that have passed the criteria. In parts the register will list a range or series of products and in other parts the register lists the products with their ratings. A brief procedure on how to have a product listed on the register is written at the bottom of the document.

The register is a "live" document that will change to reflect the products on the Namibian market. The register listed here is therefore a reflection of the products that have been evaluated and passed up until the end of April 2006.

REGISTER OF RECOMMENDED PRODUCTS

for Solar Home Systems, Solar PV Pumps and Solar Water Heaters

Version: June 2006 (Rev 0)

Commissioned by Ministry of Mines and Energy
for the
Barrier Removal to Namibian Renewable Energy Programme (NAMREP)

The purpose of the Register of Recommended Products is to set a minimum standard for products purchased through the Solar Revolving Fund facility. The criteria for the assessment of the products suitability under Namibian conditions are considering mainly quality, reliability and life expectancy issues.

SOLAR HOME SYSTEMS

Solar PV modules

BP Solar, amorphous, 10W/20Wpeak
BP Solar, amorphous, 43W/50Wpeak
BP Solar, mono, 50/70/75/80Wpeak
BP Solar, poly, 5/10/20/40/50/65Wpeak
BP Solar, poly, 60/80/125Wpeak
Kyocera, poly, 40 to 130Wpeak
Sanyo, HIT, 56/62Wpeak
Sharp, poly, 80/125Wpeak
Shell Solar (Solar World), CIS, 10 Wpeak
Shell Solar (Solar World), mono, 20 to 50Wpeak
Shell Solar (Solar World), mono, 80/85Wpeak
Solara S Series, 50/125Wpeak
Sunset, mono, 65/80Wpeak
Total Energie/Tenesa, mono, 120 to 140 Wpeak
Total Energie/Tenesa, poly, 50 to 140 Wpeak

Batteries

Raylite, Leisure RR1, 12V, 60Ah (C20)
Raylite, Leisure RR2, 12V, 96Ah (C20)
Willard, Leisure 774, 12V, 90Ah (C20)
Willard, Solar 105, 12V, 105 Ah (C100)
Willard MT range, 2V, 240 to 720Ah (C100)
Willard RT range, 2V, 290 to 880Ah (C100)

Charge controllers

Engineerging Centre, EcSAT range, 12/24V, 10A, series
Morningstar, Sunsaver range, 12V, 6/10/20A
Phocos, CML range, 12/24V, 5/10/15/20A, series
Phocos, CX range, 12/24V, 8/16/32A, series
Steca, PR range, 12/24V, 10/15/20/30A, shunt
Steca, PR range, 12V, 3/5A, series
Steca, Solarix range, 12/24V, 8/12/20/30A, shunt
Steca, Solsum range, 12/24V, 6/8/10A, shunt

REGISTER OF RECOMMENDED PRODUCTS

for Solar Home Systems, Solar PV Pumps and Solar Water Heaters

SOLAR HOME SYSTEMS

Lamps

Phocos, CLI range, 12V, 15/30W
Phocos, CLI range, 12V, 5/7/11W
Phocos, SLI range, 12V, 0.4/1.2W
Steca, SolLed range, 12V, 0.35/0.7W
Steca, Solsum range, 12V, 5/7/11W
Steca, ULed range, 12V, 0.9/1.2/1.5W

Inverters

ASP, 12V, 150VA
Studer, 12V, 200/400VA
Sunset, 12V, 400/600/800W
Victron, 12V, 180/350/650VA

PHOTOVOLTAIC WATER PUMPS

Solar PV modules

All modules listed under SHS as well as:
BP Solar, mono, 140/150Wpeak
BP Solar, poly, 110/120/1140/150Wpeak
Kyocera, poly, 158 to 200Wpeak
Sanyo, HIT, 200/205/210Wpeak
Sharp, mono, 175/180/185Wpeak
Sharp, poly, 140 to 200Wpeak
Shell Solar (Solar World), poly, 150/160Wpeak
Sunset, mono, 110 to 170Wpeak
Total Energie/Tenesa, mono, 190 to 210 Wpeak
Total Energie/Tenesa, poly, 160 to 210 Wpeak

Pumping subset

Grundfos, SQFlex, centrifugal, 30m head
Grundfos, SQFlex, helical rotor, 120m head
Juwa, 200m head
Lorentz, centrifugal, 30m head max
Lorentz, helical rotor, 240m head max
Shurflo, Series 9300, 70m head
Solastar, diaghragm pump
WaterMax, diaphragm pump, 150m head max

Solar WaterHeaters

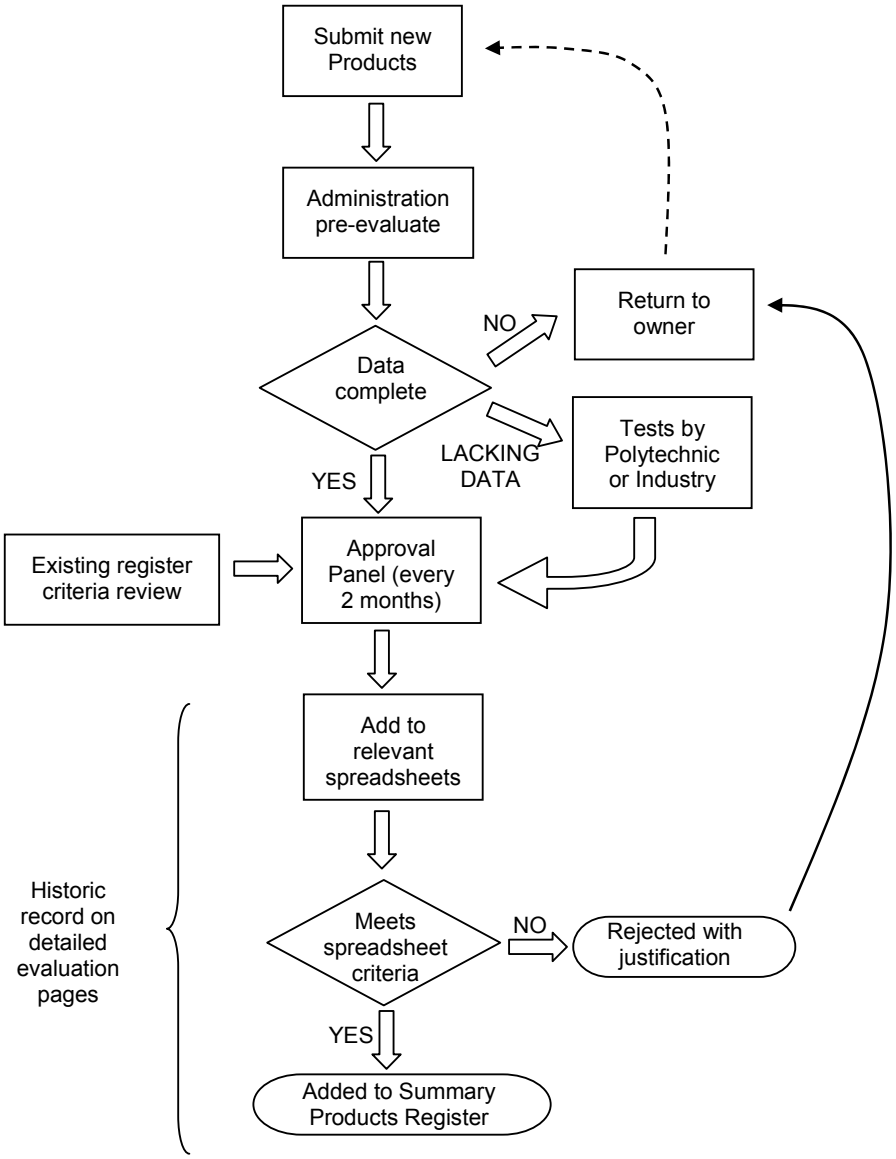
Chromagen
Megasun
Solahart
Solardome Sunstor
SunTank
Xstream Solarstream

Procedure for applying to have a product listed:

1) Submit a detailed product specification sheet to NAMREP (Fax: 061 - 284 8200) with your contact details.
2) Provide additional information if required.
3) The product will be evaluated by a NAMREP-led panel and added to the register if the criteria are met.

2.4 MAINTAINING THE APPROVED PRODUCTS REGISTER

While the products register must contain approved and quality products it must too not exclude potential new comers from being added to the list. Therefore the fairest method of maintaining this approved products register would be to create a product approval panel that will meet periodically (at least every two/three months) and regularly to consider new products for addition. The panel should consist of staff from the Ministry of Mines and Energy, the PolyTechnic of Namibia and the solar industry.



The manufacturers or distributors will submit an application to the administrator of the register by providing the technical information of the product, addressing specifically the evaluation criteria of this particular product category. If the data is incomplete the application is returned to the owner or the product is sent for evaluation by the Polytechnic or industry. It is recommended that the Ministry allocates some funds towards the expenses that are incurred for the testing and the evaluation of the products.

The complete applications are forwarded to the panel and the criteria added to the relevant spreadsheets. The panel then assesses whether the product meets the criteria. The process of evaluation and selection should be transparent and consistent. The detailed evaluation pages hold record of the product assessment and only those that pass the criteria are added to the Summary Products Register.

The assessment criteria for the products can be reviewed at each panel meeting and revised, removed or added to as judged by the panel.

The procedure of maintenance of the register should be as follows:

3 CODE OF PRACTICE

Numerous Codes of Practices were studied; they are listed in section 5. It was found that Codes of Practice have been developed in a number of countries for Solar Home Systems and Solar Water Heaters. However, this is not the case for Photovoltaic Water Pumping, where only a very limited amount of published work could be sourced.

Due to the varying degrees of complexity and the often very academic content of the Codes reviewed it was decided to compile Codes of Practice specifically for Namibia. This approach also allows the different Codes to be harmonised and put into a similar format. Naturally the Codes of Practice that were studied provided valuable inputs.

The Codes presented in this section build on local expertise and are for the benefit of the solar technicians of Namibia. As practical field guides, they have deliberately been kept as practical and accessible as possible, and address all the activities around the site of installation.

The Codes of Practice presented in this section include the following topics:

- Components of the system
- Safety guidelines
- Site assessment
- Installation
- Commissioning
- Maintenance
- Hand-over to customer

3.1 CODE OF PRACTICE FOR SOLAR HOME SYSTEMS

The Namibian Code of Practice for Solar Home Systems (SHS) is an installer's field guide. It describes how a SHS is installed so that the system functions as planned and the customer is satisfied with the quality of the installation.

The Code deals with all the important activities when installing a SHS, and gives hands-on guidelines on system components, safety guidelines, site assessment, installation, commissioning, maintenance, and the hand-over procedure to the customer.

The Code assumes that the customers needs have been assessed and that an appropriately sized system has been offered, which is now to be installed by the solar technician.

The Code should always be used in combination with the manufacturer's information of the SHS components that are being installed.

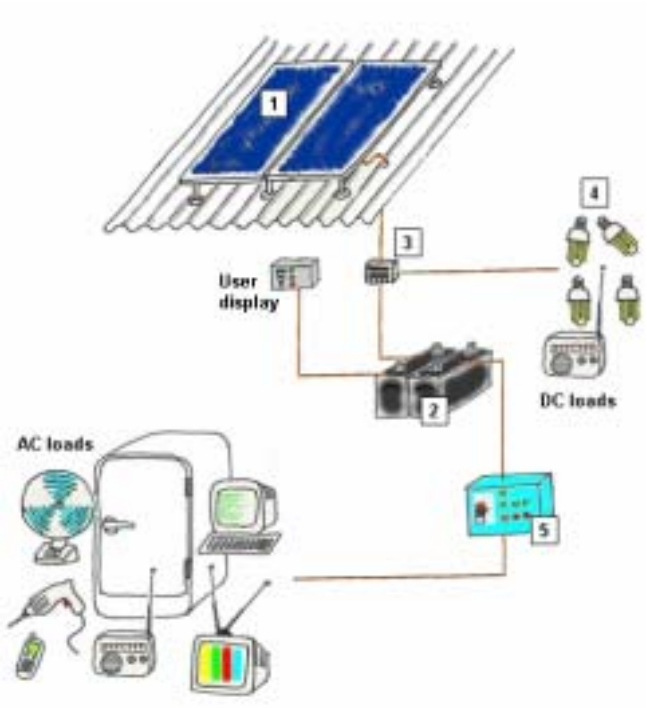
The minimum requirement for using this Code is by participation in some of the SHS training courses offered during the last years, an electrician's wire-mans license or an automotive electrician license.

This Code of Practice has been compiled from the experience in the Namibian Solar Home System sector. It was furthermore guided by the SASMSA Code of Practice, the Code of Practice for installing low-voltage PV power systems and the Universal Technical Standards for Solar Home Systems. The references are listed in section 5.

3.1.1 Components of a Solar Home System

The components of a Solar Home System consist of:

1. **Solar PV modules:** produces direct current (DC) electricity from sunlight. A **PV array** has a number of PV modules on one structure.
2. **Battery:** stores the electrical energy from the PV module/array.
3. **Charge controller:** the manager of the battery – it controls the charging of the solar PV array into the battery and controls the discharging of the battery to the DC loads such as lamps, radio and TV.
4. **Lamps:** fluorescent lamps and Light Emitting Diode lamps are used for lighting.
5. **Inverter:** to convert the battery's direct current output into alternating current (AC), which is the standard household electricity as used in the city. Not every SHS has an inverter.



3.1.2 Safety guidelines

BATTERY: A battery stores energy. It needs to be treated with care! Therefore:

- Always carry/transport a battery with the terminals on top.
- Transport the battery safely by **covering** the terminals and by going **slow** over bumpy roads.
- Do not short-circuit the battery as a test of how "strong" or full the battery is. Use a hydrometer and a multimeter for measurements.
- Batteries contain sulphuric acid, which is a highly corrosive and aggressive fluid.

  - Protect your eyes and hands when working with batteries.
  - Thoroughly rinse your hands or other body parts with water if they have come in contact with any fluid coming from the battery.
  - Neutralise acid spills with bicarbonate of soda (1kg to 10litres of water).
- Always use tools that are insulated (covered with plastic or a plastic tape) to avoid short-circuiting the battery terminal.
- Explosive gases develop when the battery is being charged.
  - For this reason it is important that there is sufficient ventilation and that there are no open flames in the room of the battery.
  - Ensure that all connections are tight to avoid sparking!

INVERTER: An inverter converts 12VDC (or other DC voltages to 230VAC).

- The inverter generates voltages up to 300V. Shock may cause serve harm and injury.
  - Make sure that all 230VAC cables used are undamaged and insulated.
  - Make sure that all open contacts are within enclosures (Distribution Boards) which are closed with screws, nuts or locks.
- Follow the South African Standards for wiring of premises (SANS 0142).
- Never connect the inverter to a mains supply or to a system powered by a diesel generator! This would destroy the inverter.

3.1.3 Site assessment

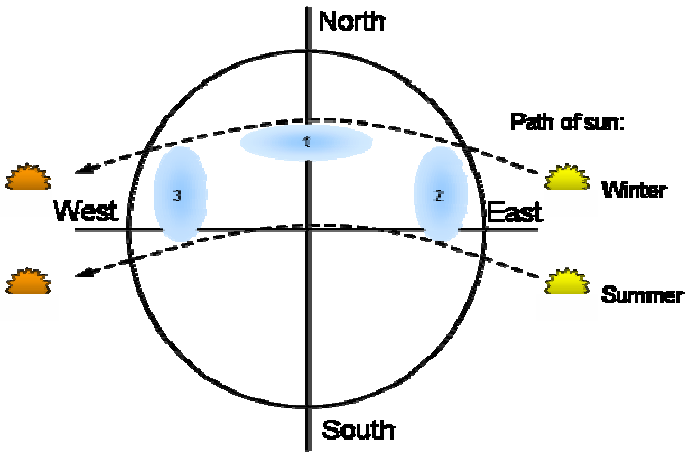
Before starting with the installation first make sure that the best place for the battery and the PV array has been selected. The following has to be considered:

3.1.3.1 Battery placement

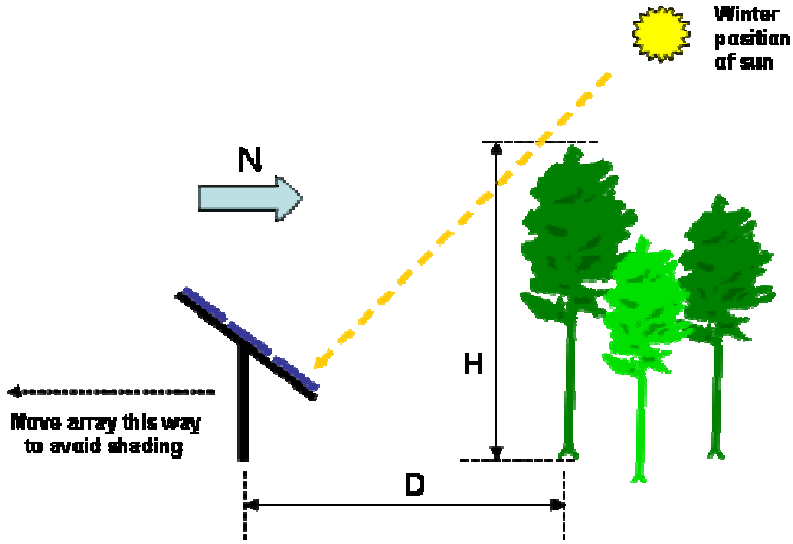
- Place batteries as central as possible so that the cable distances from the battery to the lamps are the shortest, and as close as possible to the PV array.
- Place the batteries in a cool place, away from the oven or an open flame.
- Be sure that battery placement is in a dry place with good ventilation.
- Place the batteries where they are accessible for maintenance.
- If possible avoid placing the battery in a bedroom.
- Keep the batteries away from children.

3.1.3.2 Solar PV array placement

- The array must be as close to the batteries as possible.
- Make sure that there will be no shade on the PV array from trees or buildings throughout the day. Also confirm that no shading will occur during the other part of the year. Refer to the diagram below:



- The diagram is a view from above.
- Imagine that you stand at the centre of the cross facing north.
- The path of the sun is from east to west. It is shown for summer and for winter.
- In summer, at midday, the sun passes more or less right over you.
- In winter, the path of the sun is much lower. At midday, the sun is more or less midway between the horizon and the summer position.
- Ensure that no trees and structures will block the sun in Area 2 (morning) and 3 (late afternoon). If there are structures then these need to be at a distance so that the sun will shine on the PV array one hour after sun-up and up until one hour before sunset.
- Check that there are no trees or structure blocking the sun in winter (Area 1). If there are structures, than move the array position south by the same distance as the structure is high. Refer to drawing below (Distance D must be larger than Height H):



- A roof installation is often safer than a pole installation (reduces theft).

- A pole-mounted installation is more flexible (independent of roof orientation and roof angle) but is more costly, requires more materials and needs longer cables.

3.1.3.3 Charge controller placement

- Install the charge controller in a position where it can be seen - unless the system has a Power Gauge.
- Keep the distance between the batteries and charge controller as short as possible (less than 1.5m).
- Place the charge controller into the same area as the batteries so that the internal temperature compensation (which is used in many charge controllers) can work properly.

3.1.4 Installation

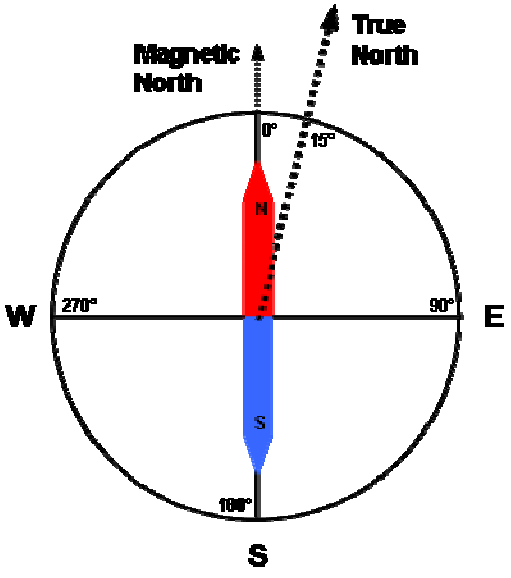
Once it is clear where the main components of the SHS are to be placed, the installation can begin. The following installation guidelines are good practice:

3.1.4.1 Batteries

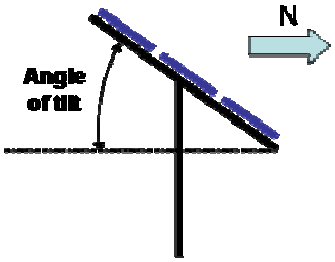
- Install the battery(ies) in a vented plastic box with a plastic lid.
- Place the plastic box on a flat surface that is out of reach of children and livestock.
- Ensure that the battery connectors (posts or threaded studs) can be reached and that the “eye” of the battery (if there is one) can be seen from above.
- Engrave the installation date on the battery(ies) - if the supplier did not do this.

3.1.4.2 Solar PV array

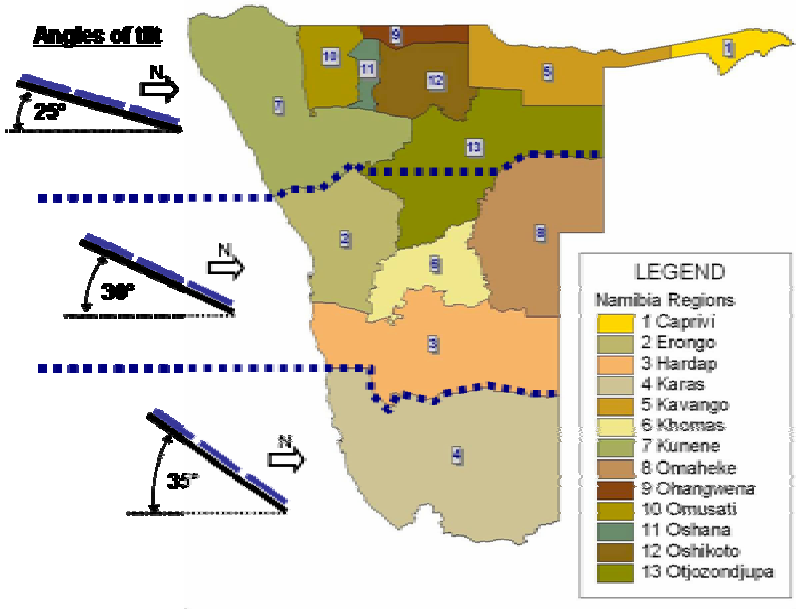
- The array must face north by ± 10°. Remember that true North is approximately 15° East of magnetic North. Refer to the diagram of the compass below:



- The angle of tilt is the angle between the horizontal surface and the PV array surface. Refer to diagram below:



- The array's angle of tilt should be about 25° in northern Namibia, 30° in central Namibia and 35° in southern Namibia. Refer to the map of Namibia below, showing the different regions.



- In a roof-mounted array allow for air flow under the modules (to keep them cooler) – do not place them flat on the roof!
- In a pole-mounted array, the height of the bottom edge of the array should be at least 2m above the ground level. Higher will be safer!

3.1.4.3 Inverter

- The inverter draws a lot of power from the batteries (high amps). It must be close to the batteries with the cable length not exceeding 1.5m.
- Be sure that there is about 10 cm of space around the inverter for ventilation.
- Keep out of direct sunlight and away from source of heat.
- Refer to the manufacturer's installation instruction. Most inverters are best installed vertically against the wall.

3.1.4.4 Lights and socket outlets

- Each light must have its own switch.
- Interior lights: Use pull-switches.
- Exterior lights: Use an internally fitted wall mounted switch for the outside light or a water proof light switch.
- Light fittings such as a bulkhead must have all entries closed to avoid insects entering the light.
- Light fittings that are installed outside must be fully enclosed. If the light can get wet at the place of installation then the cable entry into the light must be from the bottom of the light.
- The DC socket outlets should be as close to the charge controller as possible.

3.1.4.5 Refrigerator

- Place the refrigerator in the coolest room in the home, away from the stove/fire place.
- Make sure that the refrigerator is on level ground.
- Leave a gap of at least 50mm between the unit and the wall (for air circulation).

3.1.4.6 Over-current protection

There are a number of ways to protect a Solar Home System. Over-current protection is either integrated in a component (e.g. charge controller, inverter) or as a protective element in the wiring. The following parts of a SHS need protection:

- **Batteries:** Requires protection as it can produce many hundreds of amps. Protection is either:
    - integrated in the charge controller as a wire fuse element, or
    - as electronic protection (both of which still leave the wires between the charge controller and the battery unprotected!), or
    - as a fuse element directly at the positive battery terminal (recommended for larger systems).
- **Lamps:** These should have internal wire fuses, which blow when the lamp is faulty. This avoids putting a short-circuit on the whole circuit.
- **Inverter DC side:** This should have an internal fuse. When this fuse blows there is a critical fault in the inverter – take the inverter for repair.
- **Inverter output side:**
    - Overload and short-circuit protection – usually an electronic protection (which means that there are no wires that break and this type of protection resets itself).
    - Earth-leakage protection - to protect the customer from shock hazard when a fault occurs on the 230VAC side. This requires the earthing in the Solar Home System to be correctly installed.

The PV array side does not require protection as its output current is limited by design.

3.1.4.7 DC wiring, cables and connections

Most Solar Home Systems are 12VDC systems – low voltage systems are very sensitive to voltage drops. A SHS with high voltage drops can have problems such as: low solar current at full sun or battery does not reach 14.5V (i.e. it does not get fully recharged), or a light does not switch on due to voltage drops along the cable.

THEREFORE: Thin cables will "weaken" the solar system permanently!

Poor connections are like wires that are too thin. A poor connection will cause a voltage drop and heating at the connection.

Three golden rules for 12VDC installations

1. Keep cables short.
2. Select cables with sufficient diameter.
3. Make proper and tight cable connections.

There following aspects of wiring are discussed in the sections below:

- The cable size in relation to the amps and the length of the cable
- The type of cable
- The cable connections
- The installation of the cables

3.1.4.7.1 Cable size

The **amps** that flow through a **length** of cable will determine the **size** (cross-sectional area in mm^2) of the cable.

The following table lists standard cable sizes for different array sizes:

Cable run	Length	50W$_{peak}$	100W$_{peak}$	200W$_{peak}$	400W$_{peak}$
Array wiring			4mm²	4mm²	6mm²
Array to charge controller (Surfix cable – not in direct sun)	10m 15m	4mm² x 2 6mm² x 2	6mm² x 2 use trailing		
Array to charge controller (Trailing cable)	10m 15m	2.5mm² x 4 4mm² x 4	4mm² x 4 6mm² x 4	6mm² x 4 10mm² x 4[1)]	10mm² x 4[1)] 16mm² x 4[1)]
Charge controller to battery	1.5m	4mm²	6mm²	10mm²	16mm²
Battery set wiring	0.5m		6mm²	10mm²	16mm²
Charge controller to 2A outlet	2m	2.5mm²	2.5mm²	2.5mm²	2.5mm²
Charge controller to 5A outlet	2m	4mm²	4mm²	4mm²	4mm²

[1)] The terminals of many charge controllers will not be large enough for this size cable. The cable needs to be terminated in a junction box or via a circuit breaker.

The following table lists inverter to battery cable sizes for different inverter sizes:

Length	200W	400W	600W
1.5m	4mm²	10mm²	16mm²

The following table lists charge controller to lights cable sizes for different power light:

Length	7W	9W	11W	15W	2 x 7W	2 x 9W	3 x 7W
1 to 10m	1.5mm²	1.5mm²	1.5mm²	2.5mm²	2.5mm²	2.5mm²	2.5mm²
10 to 15m	1.5mm²	1.5mm²	2.5mm²	2.5mm²	2.5mm²	4mm²	4mm²

Cut off any excess wiring – the shorter the wires the better (stronger) the system!

3.1.4.7.2 Selecting the right type of cable

Different cable types are required for different parts of the Solar Home System wiring.

Cable	Cable type
Solar PV array wiring [1)]	Flexible multi-strand
PV array to charge controller [1)]	Roof mounted: Surfix (not in direct sun) Pole mounted: Trailing cable
Charge controller to battery	Flexible multi-strand
Battery set wiring	Flexible multi-strand
Battery to inverter	Flexible multi-strand
Charge controller to lights	Surfix
Charge controller to DC outlet	Surfix

[1)] Use UV resistant cable here if available!

[2)] Surfix cable is ideally suited for a low voltage house wiring installation as the stiffness of the cable makes for a neat installation.

3.1.4.7.3 Cable connections

Cable connections can make or break a system even with the best quality components and the right cable sizes. One loose connection can render a system non-functional!

The following two cable connection methods are recommended:

1) **Terminal connection**: The cable end is directly screwed directly into a terminal block:

- Flexible multi-strand wire: Twist the wire end of the flexible cable before pushing it into the terminal. (A note here: The problem with this connection is that the screw damages/breaks the fine wire strands – it is better to use wire ferrules).
- Copper is soft – retighten the terminal after the copper has settled (an hour later or the next day).

2) **Cable lug/wire pin connection**: A cable lug/wire pin is crimped to the wire end. This makes a solid connection

   In the case of large diameter cables, which do not fit into the terminal block (for example a 4mm² cable from the solar PV array must be terminated in a 2.5mm² terminal of the charge controller):

   - Terminate this cable either with a crimped wire pin sleeve for direct connection (preferred) or terminate in a junction box for connection to the device.

General guidelines for wire termination:

- All cables joints must be in junction boxes.
- Use fittings for lights and wall switches as junction boxes where practical.
- Fuses or any other components, which can cause sparking, should not be installed in the battery enclosure where there is a possibility of explosion due to gasses.

3.1.4.7.4 Cable installation

General guidelines for cable installation:

- Outside installation: Avoid direct exposure to the sun.
- Cable entries through sheet metal roofs: Use a gland or PVC coupling for cable protection and seal with silicone. Make the entry on the high point of the sheet metal structure.
- Run cables along the wall along vertically and horizontal lines. Do not run cables skew or diagonally.
- Fix cables every 30cm.
- Suspended cables must have suitable strain relief. Be sure that the cable is UV resistant and that the cable movement (from wind) will not cut the cable over time. Avoid suspending cables over distances longer than 2 to 3m.

When **fixing cables** use the following means:

- Brick/wood wall: Cable clips
- Basic wooden pole structure: Cable ties
- Clay walls: Chase cables into walls
- Sheet-metal walls: Use P-clips or copper-hole strip to run cables along vertical sheets.

The **colour code** for two-conductor DC wiring in Solar Home Systems are:

- Positive: Red
- Negative: Black

3.1.4.8 AC wiring, protection and grounding

The 230VAC part of the system, if installed, needs to follow SANS 0142 standards – "The wiring of premises". This is important for safety and design reasons as well as for compatibility reasons, should the premises ever be connected to the grid.

Persons working on the 230VAC system side require a wire-mans license!

Refer to the safety guidelines in section 3.1.2.

3.1.4.8.1 Wiring

The SANS 0142 standard – "The wiring of premises" applies. Take note of the following points:

- The use of surfix cable for surface mounted installation is preferred as it is better protected and its rigidity lends itself for surface mounted installation.
- House wire or surfix cable can be used for installations in conduits.
- There are a number of different cables available. The colour coding of cables is as follows:

Conductor	Surfix	House wire	Cabtyre (Type 1)	Cabtyre (Type 2)
Live	Red	Red	Brown	Red
Neutral	Black	Black	Blue	Blue
Earth	Blank	Yellow/green	Yellow/green	Yellow

- Use the correct cable diameters for light circuits ($2.5mm^2$) and for socket outlet circuits ($4mm^2$) as per SANS 0142.

3.1.4.8.2 Protection

The SANS 0142 standard – "The wiring of premises" applies. Take note of the following points:

- The output of the inverter has to be connected to an earthleakage unit.
- The neutral of the inverter will be connected to earth before the earthleakage unit.
- The earth bar must be connected to the grounding circuit (refer to section 3.1.4.8.3).
- Circuit breakers are optional as the inverters used in SHSs are unable to trip the breaker (insufficient peak amps to trip the magnetic overload protection).
- The earthleakage unit (and the circuit breakers) has to be housed in a distribution board.
- An inverter can be connected to existing house wiring provided that:
    - The above conditions are fulfilled.
    - No other generator/grid is connected to the same circuit (connecting a diesel generator to a system with an inverter requires a double pole change-over switch – consult your supplier).

3.1.4.8.3 Grounding/Earthing

Grounding, also referred to as earthing is the provision of a low-resistance conduction path from points in the SHS to the earth. SHSs that use an inverter should always be grounded. There are two types of grounding:

- Grounding of equipment casings (e.g. the PV array frames, support structure, inverter casing, distribution board etc)
- Grounding of the AC electrical circuit. Do not ground the positive or negative DC rail!

Grounding of equipment

The following items are to be grounded with 10mm² bare copper earth wire (BCEW):

- The metal roof of the building (if applicable)
- The PV array structure
- The inverter casing (earth)
- The Distribution Boards (DB) earth bar

The above items are to be connected to an earth spike (copper, round, 15mm diameter), driven at least 1.5m deep into the ground. In rocky locations run BCEW in the trench and place the earth spike horizontally in the trench. The earth spike will be positioned near the PV array pole structure.

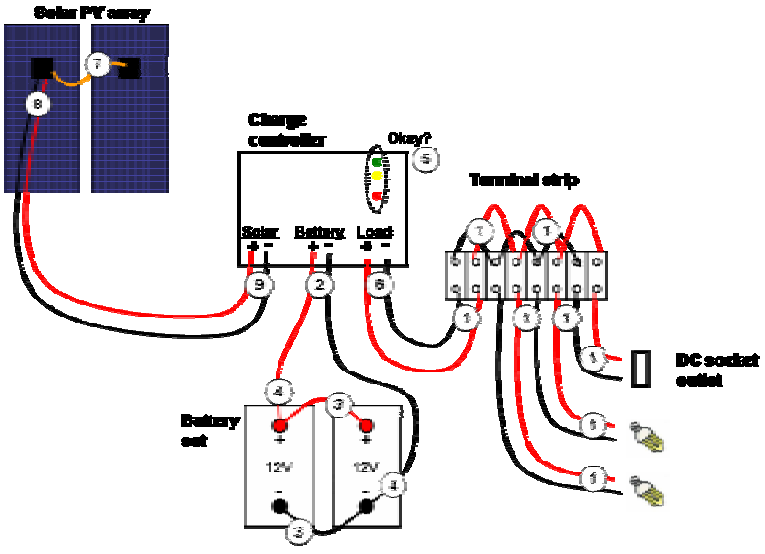
All connections will make use of cable lugs crimped to the BCEW and bolted to the array structure, the sheet metal of the roof (if applicable), the inverter earth potential and the DB earth bar. Do not twist any connections together as they will not last.

Grounding of the electrical circuit

The neutral output of the inverter will be connected to the earth bar in the DB (the inverter requires a floating, transformer isolated output for this wiring layout) before feeding into the Earth Leakage Unit (ELU). This provides the neutral to earth connection.

3.1.4.9 Connecting the components

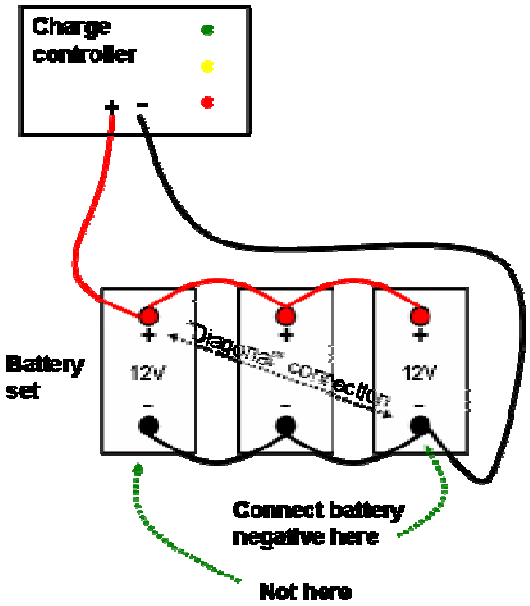
Once all the components have been installed and the cabling is in place, connect the system in the following sequence:



1) Connect all the lamps and socket outlets up to the charge controller load output - leave the load wiring at the charge controller disconnected for now.
2) Connect the battery wiring at the charge controller terminals.
3) Connect the batteries within the battery set – all batteries in parallel in a 12VDC battery set.
4) Connect the charge controller wiring to the battery terminals. Now the first components of the SHS are active.
5) Confirm that the charge controller is operational.
6) Connect the load wiring at the charge controller and test lamps and socket outlets.
7) Connect all the modules in the PV array.
8) Connect the PV array to charge controller cable at the main junction box at the array.
9) Connect the PV array wiring to the charge controller and confirm that the battery is charging (daytime).

To deactivate a SHS, follow the above sequence in reverse.

Observe the battery connections when connected in parallel: Connect the cables to the charge controller and the inverter “diagonally”. Refer to diagram below:



3.1.4.10 Labelling

The following components require labelling:

- Batteries: Warning of explosive gas, sulphuric acid and short-circuit.
- Charge controller terminals and system voltage (e.g. 12VDC).
- Fuse holder in charge controller stating the rating of the fuse (if applicable).
- DC socket outlet polarity.
- Inverter AC wiring: Live and Neutral (if applicable).
- Distribution Board: Voltage and circuit breakers (if applicable).

3.1.5 Commissioning

Commissioning is the procedure by which the installed SHS is tested and certified to be in fully operational condition. Commissioning is a very important step as it can show where mistakes have been made during the installation. Finding and resolving a mistake at this stage often saves another trip to the site in future.

Commission the installed system as follows:

- Test all basic functions of the system, such as the lights, socket outlets and solar charge current.
- Test those lights that are furthest away from any branched circuit while the solar charge is off.
- Test whether the voltage drops under full load conditions are acceptable:
    - Measure voltage at the PV array and then at the battery (this will only work if there is a clear sky and if the charge controller is not regulating the batteries, e.g. at about 14.4V). Ideally the voltage difference should be less than 1V.
    - Switch on the light that is furthest away from the battery. Measure the voltage at the light terminals and then measure the battery voltage. Ideally the voltage difference should be less than 0.6V.
- Retighten all electrical connections after one or more hour of the first installation.
- Make sure that the terminal screw is not tightened on the cable insulation.
- Pull lightly at cables to make sure that the connections are sound.
- Clean-up and make good:
    - Seal holes in walls
    - Clean-up installation site

3.1.6 Hand-over to customer

During the hand-over of the system to the customer, the installer has the duty to:

- Explain the basic operation of the SHS.
- Explain the system's daily capacity.
- Explain how the system can be expanded in future
- Provide system documentation:
    - SHS Operating Manual.
    - Explain the User Guide.
    - Complete the installation record noting component details and serial numbers.
    - Leave any documents that are specific to the system with the customer (for example the charge controller and inverter booklets).
- Explain what maintenance task have to be performed by the customer on a monthly basis. This is:
    - Check the battery water (if possible) in the battery cells once a month. Top-up with distilled water so that the plates in the battery cell are covered. Don't overfill with water.

  - Keeping the battery clean with a damp cloth.
  - Clean the PV array (dust, bird droppings).
  - Check and remove any shade on the PV array (tree branches).
- Explain to the customer that you will return for two maintenance and inspection visits after one year and after two years and what your duties will be.
- Explain how to install any spare parts
  - Lamps.
  - Fuses.
  - Battery water (distilled water).
- Provide contact details of service provider: provide customer with your own contact details, and those of the SHS supplier.
- Explain Warranty conditions: consult SWH supplier beforehand, and provide the customer with a written guarantee for the system and installation.
- Explain in which way the system is insured (if that is the case).

If for some reason the system is not complete (e.g. not all the modules were available) then inform the customer about this and agree on when the remaining items will be delivered and installed.

3.1.7 Maintenance

The maintenance tasks described here refer to the maintenance items that the solar technician needs to perform after the system has been in operation for half a year to a year. This level of maintenance, which is over and above the maintenance performed by the customer, should take place once or twice a year:

- **Battery:** Clean the battery with a damp cloth of dust, salts (oxidisation) and acid mist (from battery caps).
- **Battery connections:** Clean terminals of any oxidisation (white stuff). A badly oxidised terminal will cause the wire connection to corrode. This will cause a problem in the future – rather redo that connection immediately. Be sure to cut off enough of the oxidised cable so that the new connection can be solid (the oxidisation often “creeps” up in the cable, making it seem very stiff – cut that part off).
- **Battery with open cells:** Check the water level: Top-up with distilled water if low so that the plates in the battery cell are covered. Don’t overfill with water. Wipe the battery dry after topping up.
- **Connections:** Test cable connections by pulling. Retighten connections. Corroded connections need to be disconnected, cleaned or redone and reconnected.
- Confirm that the customer is doing the **monthly maintenance** as explained in the hand-over to the customer:
  - Topping up of battery water.
  - Keeping the battery clean.
  - Cleaning the PV array (dust, droppings).
  - Check and remove any shading on the PV array.

3.2 CODE OF PRACTICE FOR PHOTOVOLTAIC WATER PUMPS

The Namibian Code of Practice for Photovoltaic Water Pumping (PVP) describes how to properly install a PVP so that it will function as per design and the customer is satisfied with the quality of the installation.

The Code deals with all the important activities when installing a PVP, and gives hands-on guidelines on system components, safety guidelines, site assessment, installation, commissioning, maintenance, and the hand-over procedure to the customer.

The Code assumes that the customers needs have been assessed and that an appropriately sized system has been offered, which is now to be installed by the solar technician.

The Code should always be used in combination with the manufacturer's information of the PVP components that are being installed.

The minimum requirement for using this Code is past participation in some of the SHS training courses offered during the last years or an electrician's wire-mans license. Some experience in plumbing is beneficial.

The Code of Practice was compiled from experience gained in the private sector, and enhanced through information from the manual "Solar Pumping for Communities".

3.2.1 Components of a PVP

There are many types of PVP's on the Namibian market, but the most common are submersible systems. A typical submersible PVP installation has the following components:

1. **PV modules:** to produce DC electricity from sunlight.
2. **PV array:** has a number of PV modules on one structure.
3. **Controller**: this unit matches the PV power to the motor and regulates the operation, starting and stopping of the PVP. The controller is mostly installed on the surface although some PVPs have the controller integrated in the submersible motor-pump set:
    a. **DC controller:** a relatively simple electronic DC controller.
    b. **AC controller:** converts DC electricity from the PV array to alternating current (AC) electricity.
4. **Motor-pump unit:** this is a submersible (below water) motor and pump unit. Some motors operate on DC electricity while others use AC electricity.
5. **Water sensor (probe):** In some PVP systems a water sensor is installed just above the pump to protect against dry running.
6. **Cables:** the following cables are used to connect:
    a. PV module to module connection
    b. PV array to controller or control unit

c. Controller or control unit to submersible pump

d. Water sensor cable

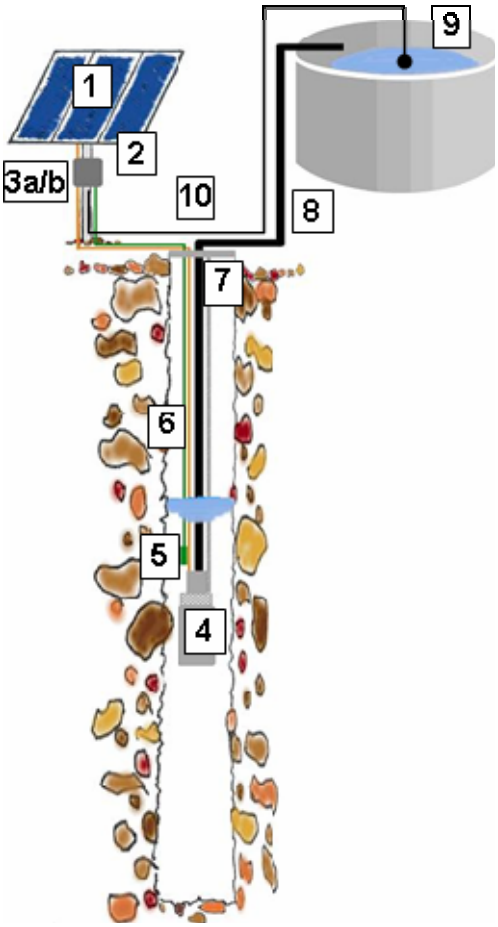
e. Float switch cable

7. **Safety Rope:** Polypropylene rope connected to the pump for installing and extracting the pump from the borehole and to avoid the pump falling into the borehole. In some cases plastic coated steel rope or stainless steel rope is used. **DO NOT use nylon rope. It rots in water!**

8. **Plastic water pipe:** connected to the pump for delivering water out of the borehole. Note that the pipe holds the pump in the borehole, while the polypropylene rope is for additional safety.

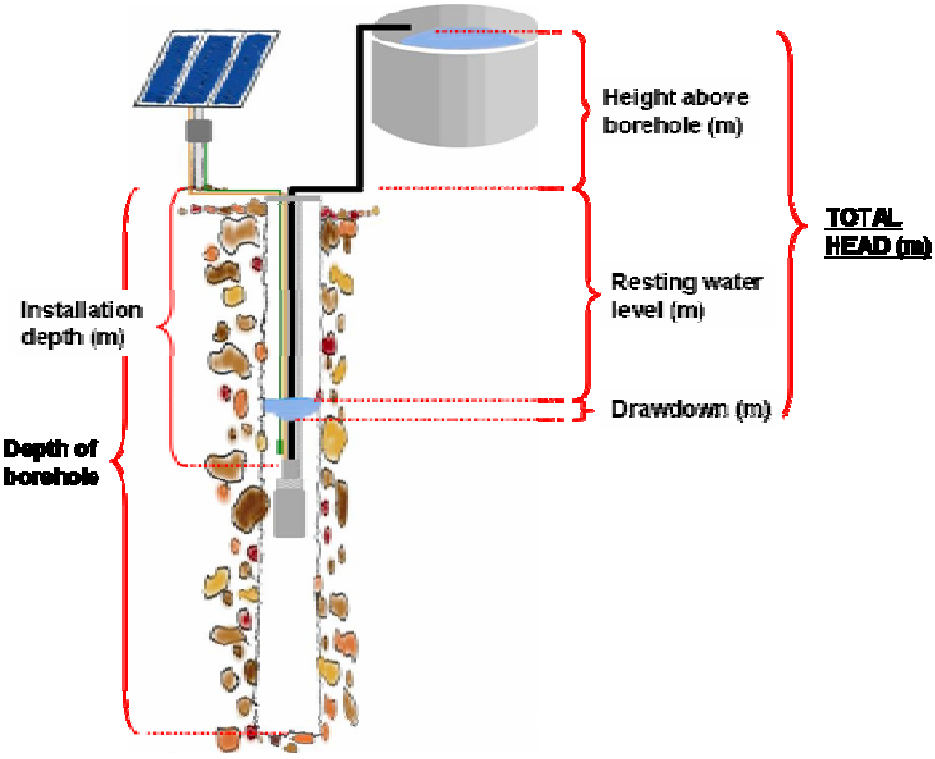
9. **Tank level switch:** A float switch can be installed in the storage tank, which switches the PVP off when the tank is full, and on when the tank level drops.

10. **Base plate:** to cover the top of the borehole and stop objects falling into the borehole. The polypropylene rope is attached to the base plate, while the cables and water pipe pass through the base plate.



3.2.2 Water heads and delivery explained

The total head over which a pump has to deliver water has a major impact on the design as well as the installation of the pump. The term “head” also means height or vertical distance. Refer to the diagram below.



The definitions are as follows (all measurements in metres):

1. **Resting water level:** this is the distance between the top of the borehole and the water table while no water is pumped from the borehole. This is best measured when the borehole has “rested” and the water level has fully recovered.

2. **Drawdown:** this is the height between the resting water level and the water level during pumping. The pump must be installed well below the drawdown level to avoid running dry.

3. **Installation depth:** the final depth of the installed pump.

4. **Total head:** this is the total vertical pumping distance that the PVP needs to pump. The total head is the level difference between the resting water level plus the drawdown plus the height of the tank inlet above ground level (m).

   Example:
   If the borehole has a resting water level of 50m, a drawdown of 10m and the tank is situated on a 30m high hill, then the total (dynamic) head is 90m.

5. **Borehole depth:** the borehole depth is the distance measured from the top of the borehole to the bottom of the borehole. Install a pump at least 5m above the bottom of the borehole to avoid pumping solids (more sand/dust at the bottom of borehole).

6. **Daily water delivery (litres per day):** this is the amount of water pumped over 6 hours (in Namibia on a fixed PV array). The hourly water delivery (daily water delivery divided by six) may not exceed the capacity of the borehole. The capacity of the borehole is known to the owner or needs to be tested by a borehole specialist. Only allow an extraction rate of two-thirds of the stated borehole capacity. Example: If the client indicates that the water capacity of a borehole is 900 l/h then the PVP should not pump more than 600l/h.

Approximate water requirements per day per head:
Cattle: 45 litres
Goats: 5 litres
Sheep: 5 litres
Pigs: 5 litres
Ostrich: 2 litres
Game: 15 litres
Elephants: 300 litres
Household: 150 litres per person

The above information has to be supplied by the customer to the supplier in order for the supplier to design a system. If this information is not available then the customers has to have the borehole tested.

3.2.3 Safety guidelines

- **Dropping components or tools down the borehole:** extreme caution and care must be taken to avoid dropping the pump or tools down the borehole. Keep all tools at a designated area on a canvas sheet near the borehole.
- **High operating voltage:** many PVPs operate at much higher DC voltage than a SHS. Voltages reach 200VDC and therefore can be a **shock hazard**! Care needs to be taken to avoid arcing!
- **Extracting a pump:** carefully extract the pump by lowering it slightly at the start and as soon as an obstruction is felt. Do not pull up if the PVP is resisting, since this could result in a permanent blockage of the borehole by the PVP. When using a vehicle to pull a PVP out, connect a metal spring between the bumper and the pulling rope, so as to detect when the PVP is resisting. **Always use controlled strength and not force!**

3.2.4 Preparation of the system

A PVP consists of a number of specialised components and accessories. The PVP design will determine what specifications these components (PV array, controller, motor, pump) and accessories (piping, cables) will need to have in order for the PVP to operate as per customer need.

The preparation of the system is a very important step. Many of the components and parts used in the installation are specialised and are not readily available out of town. Ask for the support of your supplier to make sure that you have all the required accessories and installation materials.

This section presents an overview of the PVP components and how to select the correct cable and piping for the installation.

3.2.4.1 PVP Components

In most cases the supplier from which you have ordered the PVP system will prepare the system with all the necessary accessories.

The picture below shows the typical components:

1	HDPE water pipe
2	Submersible pump in a stilling tube
3	Controller
4	User manual
5	Submersible cable
6	Water sensor
7	Water sensor cable
8	Base plate with elbow pipe fitting
9	Polypropylene rope
10	Water proof cable connection
11	Non-return valve
12	HDPE pipe fitting

The PV array structure (not shown here) needs to fulfil a number of criteria. These are:

- Security – therefore height is of an advantage and any other means to discourage a thief
- Structural strength to cope with strong gusts of wind

3.2.4.2 Choosing the correct cable type and diameter

The cables are used and selected as follows:

- **PV array cable:** the cable is used to connect PV modules to one another. The type of cable is commonly referred to as panel wire, which is a flexible multi-stranded, PVC sheathed, single-core copper cable. A cable size of 2.5mm^2 is used.
    - **Series and parallel connection:** the PV modules of most PVPs are connected in series. In some large installations a number of series connected strings of PV modules are connected in parallel.
        - Use white (or alternative) cable to connect modules in series
        - Use red cable for the positive connection in a string

- Use black cable for the negative connection in a string

- **UV resistant:** the use of UV resistant cable is recommended.

- **PV array to controller/control unit cable:** The type of cable used here is commonly referred to as panel wire, which is a flexible multi-stranded, PVC sheathed, single or multi core cable. A cable size of 2.5mm^2 to 4mm^2 is used.

- **Submersible and armoured cable:** a 3 or 4 core submersible cable is used to take the power from the surface of the borehole to the submersible unit.
  - The type of cable is either referred to as **submersible** or **trailing** cable and both cables have a double PVC insulation and are suited for submersible applications.
  - The cable diameter ranges from 2.5mm^2 to 16mm^2.
  - The diameter used depends on the size of the PV array and the installation depth.
  - When the PV array is more than 10m from the borehole, use an **armoured underground** cable between the PV array and the top of the borehole. Convert to submersible cable in a water proof junction box.
  - Refer to the recommendations of the manufacturer for cable size selection.
    - If not available then use the tables below choose the correct diameter for both types of cable.
    - **Add** the cable length of the armoured and the submersible cable together to choose the correct diameter for both types of cable.
  - Selecting cables:
    - The voltage drop is dependent on the length of the cable, the current flowing through it, the type of conductor (in our case always copper) and the diameter.
    - The tables below are calculated by allowing a 4% voltage drop in the cables.
    - Due to the large range of operating voltages of PVPs, the maximum cable length at a given array power and cable diameter is stated for the most common PVPs used in Namibia. Please note that the correct operating voltage must be selected.

MAXIMUM CABLE LENGTH: Shurflo, Watermax and Solastar

A technical note: The above DC pumps operate with linear current boosters. The linear current booster provides the necessary constant current to deliver against the installed head. The current therefore varies with installation depth and is different for the various models of pumps. A well designed PVP will choose the PV array current to match the required motor current at peak sun (the linear current booster goes into direct mode). The tables below assume a properly designed PVP but the maximum cable length remain indicative and have to be verified for each particular installation condition.

PV array nominal operating voltage: 15V and 30V

15V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
50	**21**	**34**	**42**	**51**	**68**
75	**14**	**23**	**28**	**34**	**45**
100					
150					
200					

30V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
50	**56**	**90**	**113**	**135**	**181**
75	**38**	**60**	**75**	**90**	**120**
100	**28**	**45**	**56**	**68**	**90**
150	**19**	**30**	**38**	**45**	**60**
200	**14**	**23**	**28**	**34**	**45**

Note: The 15V calculations allow a 6% voltage drop. The other calculations are based on a 3% voltage drop.

PV array nominal operating voltage: 45V and 60V

45V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
50	**127**	**203**	**254**	**305**	**406**
75	**85**	**135**	**169**	**203**	**271**
100	**63**	**102**	**127**	**152**	**203**
150	**42**	**68**	**85**	**102**	**135**
200	**32**	**51**	**63**	**76**	**102**
250	**25**	**41**	**51**	**61**	**81**
300	**21**	**34**	**42**	**51**	**68**
350					
400					
450					

60V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
50	**226**	**361**	**451**	**542**	**722**
75	**150**	**241**	**301**	**361**	**482**
100	**113**	**181**	**226**	**271**	**361**
150	**75**	**120**	**150**	**181**	**241**
200	**56**	**90**	**113**	**135**	**181**
250	**45**	**72**	**90**	**108**	**144**
300	**38**	**60**	**75**	**90**	**120**
350	**32**	**52**	**64**	**77**	**103**
400	**28**	**45**	**56**	**68**	**90**
450	**25**	**40**	**50**	**60**	**80**

MAXIMUM CABLE LENGTH: Grundfos

A technical note: The Grundfos PVP has its controller integrated in the submersible pump unit. Therefore the array DC power is transmitted to the submersible pump-motor-controller unit in the bottom of the borehole. This has been reflected in the maximum cable length calculation.

PV array nominal operating voltage: 60V and 90V

60V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
100	**113**	**181**	**226**	**271**	**361**
200	**56**	**90**	**113**	**135**	**181**
300	**38**	**60**	**75**	**90**	**120**
400	**28**	**45**	**56**	**68**	**90**
500	**23**	**36**	**45**	**54**	**72**
600					
700					
800					
900	**13**	**20**	**25**	**30**	**40**
1,000	**11**	**18**	**23**	**27**	**36**

90V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
100	**254**	**406**	**508**	**609**	**813**
200	**127**	**203**	**254**	**305**	**406**
300	**85**	**135**	**169**	**203**	**271**
400	**63**	**102**	**127**	**152**	**203**
500	**51**	**81**	**102**	**122**	**163**
600	**42**	**68**	**85**	**102**	**135**
700	**36**	**58**	**73**	**87**	**116**
800	**32**	**51**	**63**	**76**	**102**
900	**28**	**45**	**56**	**68**	**90**
1,000	**25**	**41**	**51**	**61**	**81**

PV array nominal operating voltage: 120V and 150V

120V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
100	**451**	**722**	**903**	**1,083**	**1,445**
200	**226**	**361**	**451**	**542**	**722**
300	**150**	**241**	**301**	**361**	**482**
400	**113**	**181**	**226**	**271**	**361**
500	**90**	**144**	**181**	**217**	**289**
600	**75**	**120**	**150**	**181**	**241**
700	**64**	**103**	**129**	**155**	**206**
800	**56**	**90**	**113**	**135**	**181**
900	**50**	**80**	**100**	**120**	**161**
1,000	**45**	**72**	**90**	**108**	**144**

150V	Maximum cable length [m]				
PV power [Wpeak]	2.5 [mm²]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]
100	**705**	**1,129**	**1,411**	**1,693**	**2,257**
200	**353**	**564**	**705**	**846**	**1,129**
300	**235**	**376**	**470**	**564**	**752**
400	**176**	**282**	**353**	**423**	**564**
500	**141**	**226**	**282**	**339**	**451**
600	**118**	**188**	**235**	**282**	**376**
700	**101**	**161**	**202**	**242**	**322**
800	**88**	**141**	**176**	**212**	**282**
900	**78**	**125**	**157**	**188**	**251**
1,000	**71**	**113**	**141**	**169**	**226**

MAXIMUM CABLE LENGTH: Lorentz

A technical note: The Lorentz PVP uses a DC to three phase AC inverter which is surface mounted. Therefore power transmitted to the submersible unit is a three phase AC signal. This has been taken into consideration in the calculations.

PV array nominal operating voltage: 48V and 60V

48V	Maximum cable length [m]				
PV power [Wpeak]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]	10.0 [mm²]
100	**177**	**221**	**265**	**353**	**441**
200	**88**	**110**	**132**	**177**	**221**
300	**59**	**74**	**88**	**118**	**147**
400	**44**	**55**	**66**	**88**	**110**
500	**35**	**44**	**53**	**71**	**88**
600	**29**	**37**	**44**	**59**	**74**
700	**25**	**32**	**38**	**50**	**63**
800		**28**	**33**	**44**	**55**
900			**29**	**39**	**49**

60V	Maximum cable length [m]				
PV power [Wpeak]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]	10.0 [mm²]
100	**276**	**345**	**414**	**552**	**689**
200	**138**	**172**	**207**	**276**	**345**
300	**92**	**115**	**138**	**184**	**230**
400	**69**	**86**	**103**	**138**	**172**
500	**55**	**69**	**83**	**110**	**138**
600	**46**	**57**	**69**	**92**	**115**
700	**39**	**49**	**59**	**79**	**98**
800	**34**	**43**	**52**	**69**	**86**
900	**31**	**38**	**46**	**61**	**77**

PV array nominal operating voltage: 72V

72V	Maximum cable length [m]				
PV power [Wpeak]	4.0 [mm²]	5.0 [mm²]	6.0 [mm²]	8.0 [mm²]	10.0 [mm²]
100	**397**	**496**	**596**	**794**	**993**
200	**199**	**248**	**298**	**397**	**496**
300	**132**	**165**	**199**	**265**	**331**
400	**99**	**124**	**149**	**199**	**248**
500	**79**	**99**	**119**	**159**	**199**
600	**66**	**83**	**99**	**132**	**165**
700	**57**	**71**	**85**	**113**	**142**
800	**50**	**62**	**74**	**99**	**124**
900	**44**	**55**	**66**	**88**	**110**

Note that the voltages of 48V, 60V and 72V are equivalent to 4, 5 and 6 modules in series (standard 36 cell modules). Although the modules maximum power point will be at around 15V, the convention given by Lorentz is followed – that is that a PV module has a 12V nominal voltage.

- **Sensor cables:**
  - **Water probe cable:** The cable type used here is a standard "extension" cord cable, often referred to as cabtyre cable. It consists of a multi-core, PVC sheathed, multi-stranded copper cable. A diameter of 1.5 mm^2 with two cores is used.
  - **Float switch cable:** The cable type used is a surfix cable, which is a multi-core cable, with solid copper conductors, with an aluminium screen and is PVC sheathed. Use a 2.5 mm^2 two core cable.
- **Grounding/Earthing:** Bare copper earth wire (BCEW) is used to earth the PV array structure, the controller/control box, the borehole casing as well as other metallic structures (e.g. wind pump tower) to an earth point. Use the same conductor size as the submersible cable used for a particular PVP installation. Use crimped cable lugs and bolt to structures!

A note on cable length:

- The length of the submersible cable and the water probe cable need to be 8m longer than the installation depth of the pump if the PV array is 5m from the borehole.
- Consider that the pump may have to be lowered in the future. For this reason it may also be advisable to leave some slack on the cables.

3.2.4.3 Choosing the correct piping and pipe diameter

- **Pipe:** the pipe, also referred to as the "rising main", transfers water from the pump to the storage tank.
- **Pipe diameter (mm):** the pipe diameter depends on the flow rate (the speed of water pumped). Low yield PVP's (like the Shurflo pump) use a pipe diameter of 16mm. High yield PVP's (like the Grundfos SQF and Lorentz pumps) use a 25mm or 32mm pipe diameter.

  Note that a smaller diameter pipes have a higher flow rate. This means the water column weight is less and solids in the water can be flushed out more easily.

Stilling tube:

A stilling tube is a larger diameter plastic pipe into which the submersible pump unit is installed. The larger diameter pipe reduces the amount of solids sucked into the PVP during pumping.

In addition, the plastic pipe also provides some protection to the pump unit during installation, reducing scratching and possible hooking of the pump on objects in the borehole.

- **Pipe strength (bar):** the pipe strength (thickness of pipe wall) is determined by the installation depth and is indicated in pressure class of a pipe. The deeper the PVP is installed, the higher the water pressure in the pipe and the stronger the pipe needs to be.

Pipe Strength Selection Chart	
Depth	**Pressure**
0 m – 60 m	6 bar (Class 6)
60 m – 100 m	10 bar (Class 10)
100 m – 160 m	16 bar (Class 16)
160 m – 250 m	25 bar (Class 25)

- **Pipe type:** use High Density Polypropylene (HDPE) pipe only.
    - If for some reason, metal piping has to be used then make sure to use the same or similar metals (pump and pipe) to avoid corrosion. For this reason, copper and galvanised pipes should never be directly connected to each other, but should have a suitable plastic fitting installed between them.
- **Pipelines:** PVP's can easily pump into pipelines for long distance water delivery. Get the PVP suppliers to advise.
- **Non-return valve:** most PVP's have a non-return valve where the rising main pipe connects. The non-return valve ensures easier starting of the PVP and less pressure on the pump during non-operation.

3.2.5 Site assessment

Before commencing with the installation it is important to conduct a site assessment. The following items are already decided and known before going to site:

- Type of water supply: will the PVP be installed in a borehole, a well, a dam, a river or a water storage tank?
- The daily water requirements
- The total pumping head
- A fully designed PVP with correct pipe, cable and rope length. Therefore the installation depth, the distance to the PV array and the distance to the storage tank are known prior to site visit (information supplied by the customer)

The Code will focus on the borehole installation as this is the most complex of the PVP installation. Installations in a dam, a well, a storage tank or a river are simpler versions of the borehole installation.

3.2.5.1 Borehole conditions

The following information needs to be confirmed and established:

1. **Borehole parameters:** Determine the resting water level and the overall borehole depth. Refer to the insert on the right for guidance on how to conduct these measurements.

2. **Foreign Objects:** roots and stones are often protruding from the borehole wall and may make installation and extraction of the pump difficult. Such objects can be detected by using a mirror to shine sunlight into the borehole. The depth to which the borehole casing is installed will determine how likely interference from roots and stones will be.

How to test water level and borehole depth:

Use a fishing reel and fishing line. Tie an empty glass bottle (350 ml) to the fishing line with the bottle lid removed.

Carefully lower the bottle (which contains some small stones for weight) down the borehole, while turning the reel. When the bottle touches the water level, the line goes slack. Tie a knot in the line at the reel. Bounce the bottle up and down by pulling the line a few times. This will allow the bottle to fill with water and start sinking again. Lower the bottle down the borehole until the line goes slack again. The bottle has now reached the bottom. Tie another knot at the reel.

Pull the bottle up and measure/walk-off distances to the knots. 1st knot = Resting Water Level. 2nd knot = borehole depth.

3. **Water quality:** this is determined by the amount of dissolved salts and presence of potentially corrosive minerals. If too many particles are present they can grind away at some of the submersible pumps components and increase the maintenance requirements. Preventive measures, such as stilling tubes and zinc rods, can increase the life expectancy of a submersible pump.

Zinc rods:

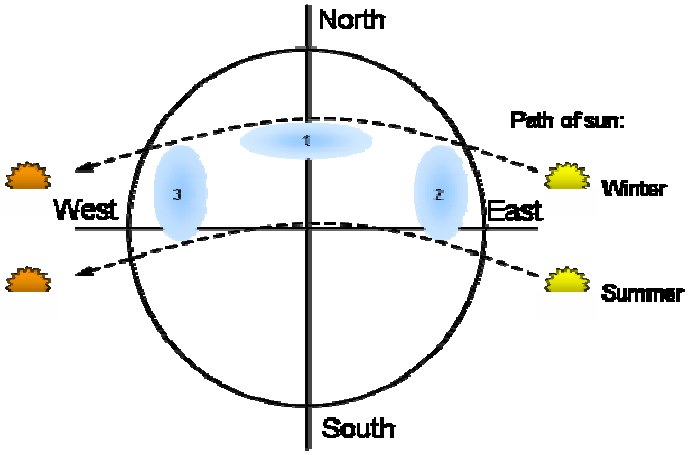
Short metal rods made from zinc are attached to the pump. In water with corrosive minerals, these minerals will corrode the zinc, rather than attack metal components of the pump itself.

4. **Temperature:** hot water will increase the wear and tear on a pump. When pumping hot water (from a hot spring, or from a pipeline lying exposed in the sun) be sure that the pump is able to operate under these water temperature conditions.

3.2.5.2 Position of the PV array

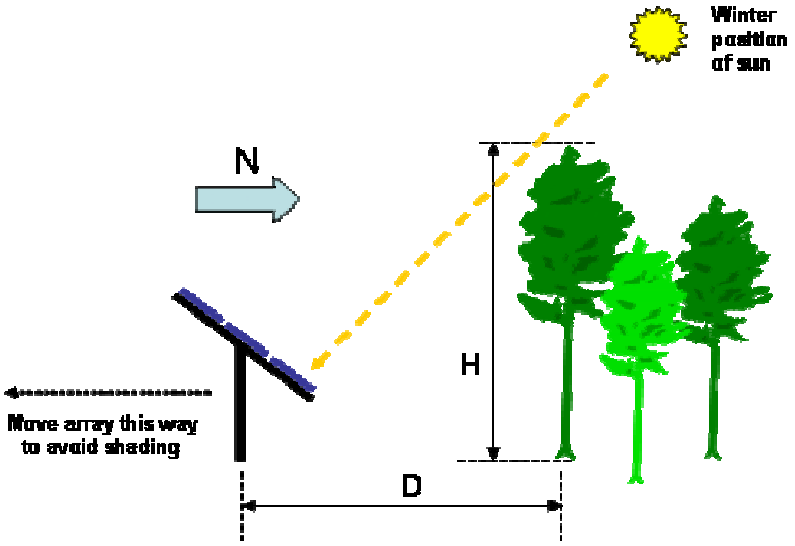
Place the PV array within 5 meters from the borehole if possible. This will keep the entire pumping installation close together, so that the area can easily be fenced off to prevent theft and damage from livestock. This will also minimise the risk of lightning damage.

- The PV arrays must face north.
- Make sure that there will be no shade on the PV array from trees, wind pump towers, hills or buildings throughout the day. Also confirm that no shading will occur during the other part of the year. Refer to the diagram below:



  - The diagram is a view from above.
  - Imagine that you stand at the centre of the cross facing north.
  - The path of the sun is from east to west. It is shown for summer and for winter.
  - In summer, at midday, the sun passes more or less right over you.
  - In winter, the path of the sun is much lower. At midday, the sun is more or less midway between the horizon and the summer position.
  - Ensure that no trees and structures will block the sun in Area 2 (morning) and 3 (late afternoon). If there are structures then these need to be at a distance so that the sun will shine on the PV array one hour after sun-up and up until one hour before sunset.

- Check that there are no trees or structure blocking the sun in winter (Area 1). If there are structures, than move the array position south by at least the same distance as the structure is high (growing trees). Refer to drawing below (Distance D must be larger than Height H):



3.2.6 Installation

Once the borehole details have been verified and a location for the PV array has been identified, the installation can begin. Installing a PVP, especially in a deep borehole (more than 80m), will require at least a three man team.

3.2.6.1 Installing the PV array

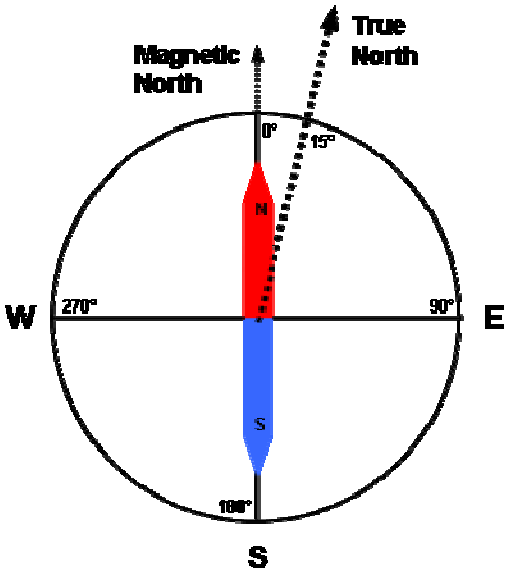
Assembling the PV modules:

- Mount and connect PV modules as per PVP supplier/manufacturer guidelines.
- Use different colours to indicate a series connection (e.g. white cable), positive connection (red) and negative connection (black).
- Run the cables so that they are not exposed to direct sunlight. Hold cables in place with cable ties.

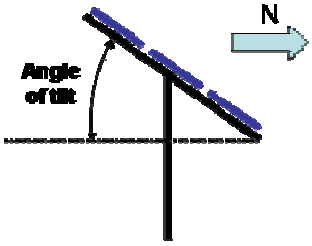
PV array:

- Dig a hole for the PV array pole(s) at the previously identified location (refer section 3.2.5.2) which is deep enough to support a single pole array structure (at least 800mm - deeper if the array is higher than 2m with more than 200W_{peak}).
- Lift the PV array up and let the array pole slide into the hole.
- Cast concrete into the hole.

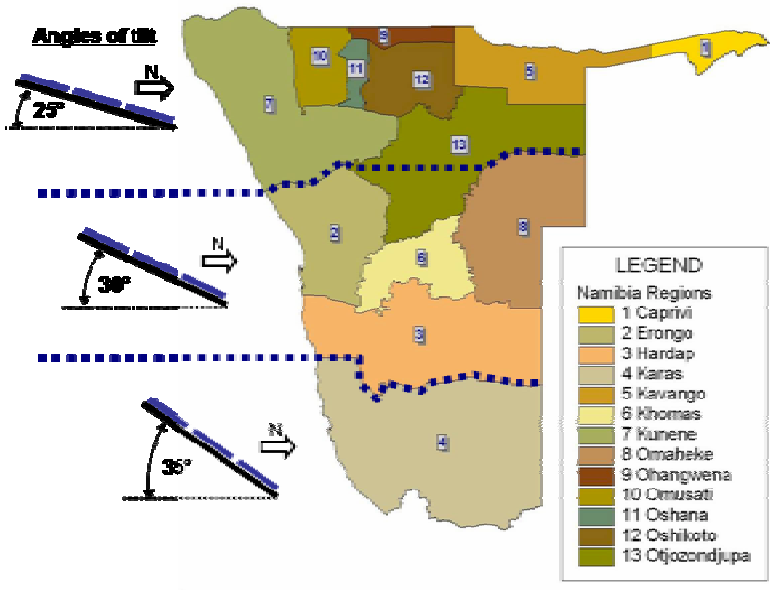
- Align the array to face north by ± 10°, and remember that true North is approximately 15° East of magnetic North. Refer to the diagram of the compass below:



- The angle of tilt is the angle between the horizontal surface and the PV array. Refer to diagram below:



- The array's angle of tilt should be about 25° in northern Namibia, 30° in central Namibia and 35° in southern Namibia to maximise the annual average water delivery. Refer to the map of Namibia below, showing the different regions.



- Align the pole into a vertical position with the spirit level.
- Secure pole in position for half a day to allow time for the concrete to settle.

Connecting the PV array to the controller/junction box:

- Mount the controller/control unit on the pole of the PV array so that it is shielded from direct the sunlight (don't exert pressure on the pole if it has not yet settled).
- Bring the PV array cables through the glands into the controller/control unit enclosure but don't connect the cables yet.

3.2.6.2 Installing the submersible pump

Preparation:

- Place the pump unit next to the borehole and roll out the pipe, cables (submersible cable and water sensor cable) and rope to their full length.
- Connect the pipe to the pump outlet fitting.
- Tie the safety rope to the appropriate place on the submersible pump unit.
- Water sensor (if applicable): strap the water sensor to the pipe just above the outlet of the submersible pump unit.
- Connect the submersible cable with a water proof connection ("Scotch cast" – A scotch cast takes many hours to settle – it is better to do that during the preparations). Some PVP's have special waterproof connection, which are supplied by the PVP suppliers.
- Strap the cables to the pipe with cable ties in 3m intervals. At the pump (bottom) and base plate (top) use more cable ties (20 cm intervals).
- Run the rope next to the pipe.
- Connect the end of the pipe (top-end) to the pipe fitting underneath the base plate.
- Connect the safety rope to the eye below the base plate (so that no part of the rope is in direct sunlight).
    - Leave an extra length of some 5m before cutting the rope. This 5m hangs in the borehole.
    - AVOID direct sunlight on the polypropylene rope.

Installation:

- Place a drum on its side next the borehole and slide the pump down the borehole, by letting the pipe, cables and rope slide over the drum. AVOID damaging the pipe, cables or rope by steering clear of sharp edges on the borehole casing, or kinking the pipe.
- Lower the pump carefully until the base plate rests on the borehole casing. There is no need to secure the base plate.
- Leave any cable slack in the borehole.
- Dig a trench (600mm deep) between the borehole and the water tank and place the HDPE pipe in the trench. The deeper the better as some animals will smell the water and dig out and damage the pipe.
- Connect the pipe to the water storage tank.

- If armoured cable is used between the borehole and the PV array: Fix a water proof enclosure (CCG or similar) at the borehole outlet. Connect the submersible cable and armoured cable in the enclosure. Be sure to use bottom entry glands.
- Dig a trench (600mm deep) between the borehole and the PV array pole and place the submersible/armoured cable and the water sensor cable into the trench.
- Float switch (if applicable): Install the float switch in the storage reservoir. Run the float switch cable (south side of reservoir) in the existing trench or via a new trench to the PV array structure.
- Fasten the cables (power cable, water sensor cable and float switch cable) to the south side of the pole and strap in place with cable ties.
- Connect the submersible/armoured cable, the water sensor cable and the float switch cable to the controller or to the control unit.
- Grounding/Earthing: Different PVP's have different earthing requirements and the PVP supplier will advise. The basic earthing configuration is to connect bare copper earth wire (BCEW) to the PV array, the controller, the borehole casing and the tank stand. Join all BCEW cables through the trenches and tie to an earth peg which is sunk 1.5m into the earth.
- Connect the PV array cable in the controller/control unit. Switch the controller on and feel/listen at the pipe outlet whether the pump is operating. Leave PVP running until water is delivered. Stop PVP.
- Retighten all electrical connections (careful with the high DC voltage at the array) after completing the installation and restart PVP.
- Finish the installation by backfilling the trenches with a layer of river/soft sand (no rocks). Then back fill with trenching materials.

3.2.6.3 Extracting the submersible pump:

- Undo the top end of the pipe from the base plate.
- Tie a rope to the top end of the pipe.
- Using the additional length of safety rope in the borehole the pump can be lowered in the borehole first, before pulling up.
    - Lowering the pump will ensure that objects that might have fallen onto the pump are dislodged and the pump can be extracted more easily. This requires loosening the baseplate and securing pipes, safety rope and cable together properly.
    - NEVER extract a pump by pulling up first! This might result in objects being wedged between the pump and the borehole wall and might make extraction of the submersible unit impossible.

3.2.7 Commissioning

Commissioning is the procedure by which the installed PVP is tested and certified to be in fully operational condition. Commissioning is a very important step as it can show where mistakes have been made during the installation. Finding and resolving a mistake at this stage often saves another trip to the site in future.

Commission the installed system as follows:

- **Test PV array voltage:** test the open circuit voltage of the array and confirm that it is what you expected (e.g. number of modules in series times open circuit voltage per module as stated on back of module).
- **Testing the operation of the PVP:**
    - Flow rate: Measure the flow rate by timing how long it takes to fill a 20-litre container. For example: If the container fills up in 2 minutes, the flow rate is 10 litres per minute, which equals 600 litres per hour. The calculation is:

      Litres per hour = size of container [litres] x 3600/time [seconds]
    - Power regulation: Turn the array away from the sun (if the structure allows this) or shade part of the array to observe that the controller regulates the power and that the flow rate reduces.
    - Controller: Check that the indicator lights on the controller/control unit indicate what you would expect (e.g. dry running indicator OFF, tank full ON or OFF, PV array power ACTIVE etc).
- **Testing the control signals:**
    - Test tank full/empty signal: lift the float switch from the tank and observe whether the PVP responds (either switches ON or OFF depending on how it is set up).
    - Test dry-running signal: In a shallow installation: Lift the pump slowly, until the pump switches off. This will also be indicated by an LED on the controller or the control unit. In a deep borehole installation, this needs to be done before lowering the PVP, by holding pump with water sensor probe in a bucket.
- **Retighten all electrical connections:** Check the connections on the PV modules, the junction boxes and the controller/control unit.

3.2.8 Hand-over to customer

During the hand-over of the system to the customer, the installer has the duty to:

- Explain the basic operation of the PVP
- Explain the system's daily delivery capacity
- Explain how the system can be expanded in future
- Provide system documentation:
    - PVP Operating Manual
    - Complete the installation record noting the component details and the serial numbers
    - Leave any documents that are specific to the system with the customer (for example for the inverter)

- Explain what maintenance task have to be performed by the customer on a regular basis. Be sure to add the maintenance requirements as listed in the documentation of the specific product that you have installed:
    - Clean the PV array (dust, bird droppings).
    - Check and remove any shade on the PV array (tree branches).
- Explain to the customer that you will return for two maintenance and inspection visits after one year and after two years and what your duties will be.
- Explain how to install any spare parts
    - Fuses
- Provide contact details of service provider: provide the customer with your own contact details, and those of the PVP supplier.
- Explain Warranty conditions: consult PVP supplier beforehand, and provide the customer with a written guarantee for the system and installation.
- Explain in which way the system is insured (if that is the case).

If for some reason the system is not complete (e.g. there were no float switches available) then inform the customer about this and agree on when the remaining items will be delivered and installed.

3.2.9 Maintenance

The maintenance tasks described here refer to the maintenance items that the solar technician needs to perform after the system has been in operation for a year. This level of maintenance, which is over and above the maintenance performed by the customer, should take place once a year:

- **General maintenance tasks:**
    - Confirm performance of PVP: Measure the flow rate by timing how long it takes to fill a 20-litre container:

      Litres per hour = size of container [litres] x 3600/time [seconds]

      If the performance has decreased considerably below the design flow rate then the pump needs to go for a service.
    - PV array: Confirm that there is no shading on the PV array and that there is no “solid” dirt on the modules.
    - Check all electrical and pipe connections: Pull at electrical connections and check mechanical fuses. Check for leaks and retighten/reseal where necessary.
- **Specialised maintenance tasks:**
    - PVPs based on brushed DC motors: extract PVP once a year and check carbon brushes on electric motor. Replace if necessary.
    - PVP’s based on diaphragms pumps: extract PVP once a year and replace diaphragm. Clean pump chambers.

3.3 CODE OF PRACTICE FOR DOMESTIC SOLAR WATER HEATERS

The Namibian Code of Practice for Domestic Solar Water Heaters is an installer's field guide on how to install a Solar Water Heater (SWH) so that the system functions as planned and the customer is satisfied with the quality of the installation.

The Code deals with all the important activities when installing a SWH, and gives hands-on guidelines on system components, safety guidelines, site assessment, installation, commissioning, maintenance, and the hand-over procedure to the customer.

The Code assumes that the customers needs have been assessed and that an appropriately sized system has been offered, which is now to be installed by the solar technician.

The Code should always be used in combination with the manufacturer's information of the SWH components that are being installed.

The minimum knowledge required to use this Code is a background in plumbing and some basic electrical house wiring skills.

This Code of Practice is guided by the South African Draft Code of Practice for installation, operation, maintenance and repair of Solar Water Heaters, the Code of Practice for manufacture and installation of Solar Water Heating Systems in New Zealand, the Code of Practice for Domestic Solar Water Heaters in Botswana, and by sector experience in Namibia. The references are listed in section 5.

3.3.1 Components of a Solar Water Heater

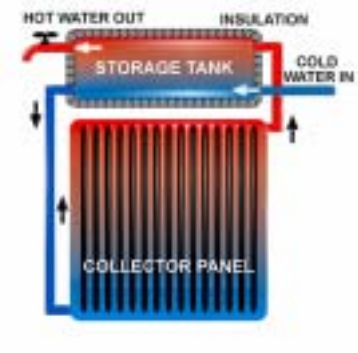
The components of a SWH are:

- hot water storage tank,
- solar collector(s),
- pipes (connection pipes between storage tank and collector(s), cold water supply and hot water delivery),
- control/regulation and safety fittings, and
- an optional electrical backup/booster element with thermostat control.

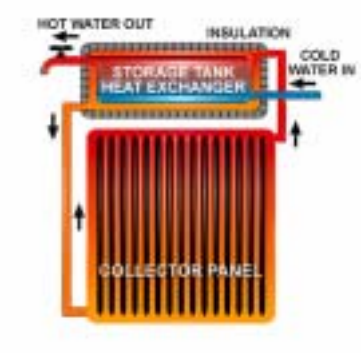
The following definitions help to understand the functions and differences between different SWHs:

- **Thermosiphon**: This is the natural circulation process that takes place when warm water rises and is replaced by cooler water. Explained:
    - As the sun's rays hit the surface of the collector, the temperature of the fluid in the collectors rises making it less dense or lighter. This hot and lighter fluid naturally moves to the top of the collector and via the pipe work into the storage tank, transferring the energy from the collectors to the storage tank water. This makes the fluid colder and heavier, which then moves to the bottom of the collectors. Refer to diagrams below.
- **Solar collector**: This is the device in which solar radiation (sunlight) is absorbed and heats the water that is circulated through the collector.

- **Glazed collectors**: Solar water heating systems generally have their collectors protected by a sheet of glass. This aids the heat absorption process by trapping heat inside the collector due to the greenhouse effect.
- **Direct system**: In this type of SWH, the water used from the system also passes directly through the solar collector.
- **Indirect system**: Also known as a **closed circuit** system. In this type of SWH, the water circulating through the solar collector is separate to the water in the hot water tank. A separate closed circuit containing a water/glycol fluid mixture transfers the heat from the collector to the water stored in the tank via a heat exchanger.



Direct SHW

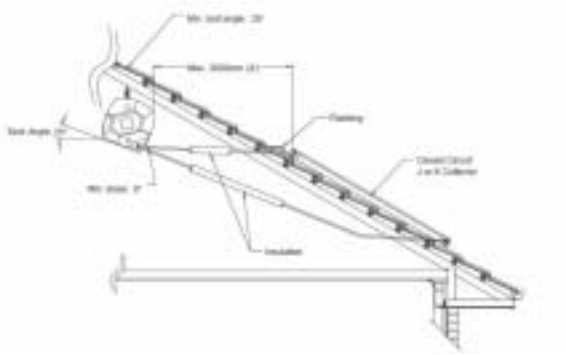


Indirect SWH

- **Close coupled system**: In a close coupled system the storage tank is located close to and usually above the collectors.
- **Split system**: In a split system the storage tank is located away from the collectors.

Typical close coupled SHW

(Source: Solardome)



Typical split SWH

(Source: Solahart)

- **Passive system**: A passive system is one where the heating takes place as a result of a natural thermosiphon process.
- **Active system**: In an active system the flow from the collector to the tank must be assisted by a pump.

3.3.2 Safety guidelines

It is important to be aware of the possible dangers that can arise when installing a SWH. The weight of the SWH unit, the height of roof structures, the angle and strength of roof structures as well as the connection to electricity all make the installation of a SWH dangerous, and an installer needs to be aware of what can happen during an installation. The safety guidelines should therefore be followed in order to avoid injury to the installer or other persons at the site of installation, and also to avoid damage to the building.

Use the following guidelines:

- Always place your ladders so that they are stable!
- Be sure that your shoes grip on the roof surface – be very careful if the roof is wet!
- Find a way to secure tools used during a roof installation from slipping or falling down the roof.
- Only walk on those roof areas that are fastened to the roof structure.
- Warn the occupants of the house where the installation is undertaken to stay away from the installation and roof area during the entire installation process.
- The SWH system weighs between 200kg to 400kg when the water tank is full. Make sure that the roof structure is sufficiently strong to support that weight.
- Plan to install the SWH system over at least three trusses (flat roof structures).
- Always try to locate the storage tank directly above a batten or purlin.
- Secure a safety rope to the hot water tank. One or two persons must be on the roof holding the safety rope when other persons are lifting the tank on to the roof.
- Always use four persons to lift a glazed collector on to the roof (breakage from a glazed collector can be extremely dangerous).
- Electrical house wiring needs to be done in accordance with the Code of Practice for the wiring of premises (SANS 0142). Working on the electrical wiring requires a qualified electrician!
- Switch off the power to the electrical backup element when working on the wires. Be sure that somebody else cannot switch on the power during the installation!

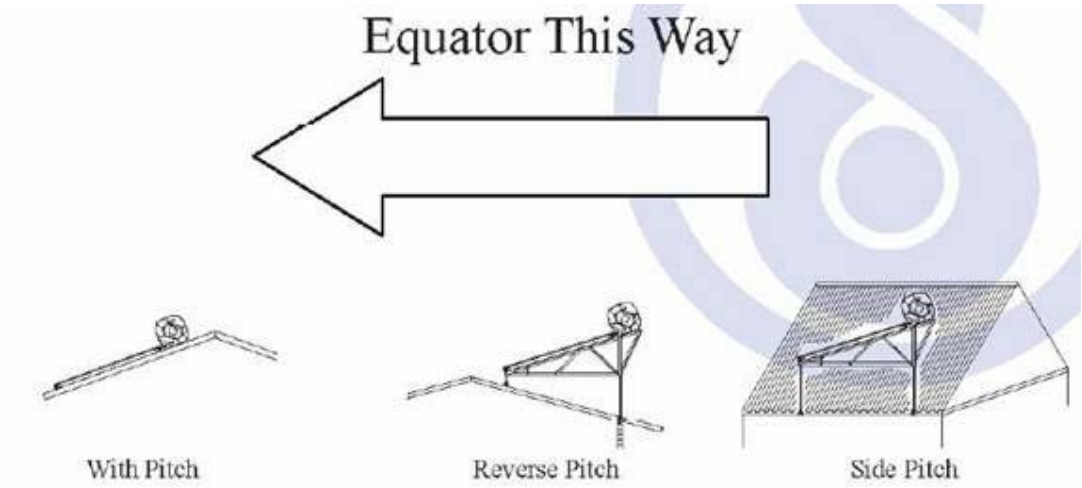
3.3.3 Site Assessment

Before the installation can begin, it is important to assess the conditions on the site. This assessment will determine many of the installation requirements. Once the assessment has been completed, the findings must be discussed with the customer. The customer should be made aware of any of the installation and performance implications related to the proposed place of installation.

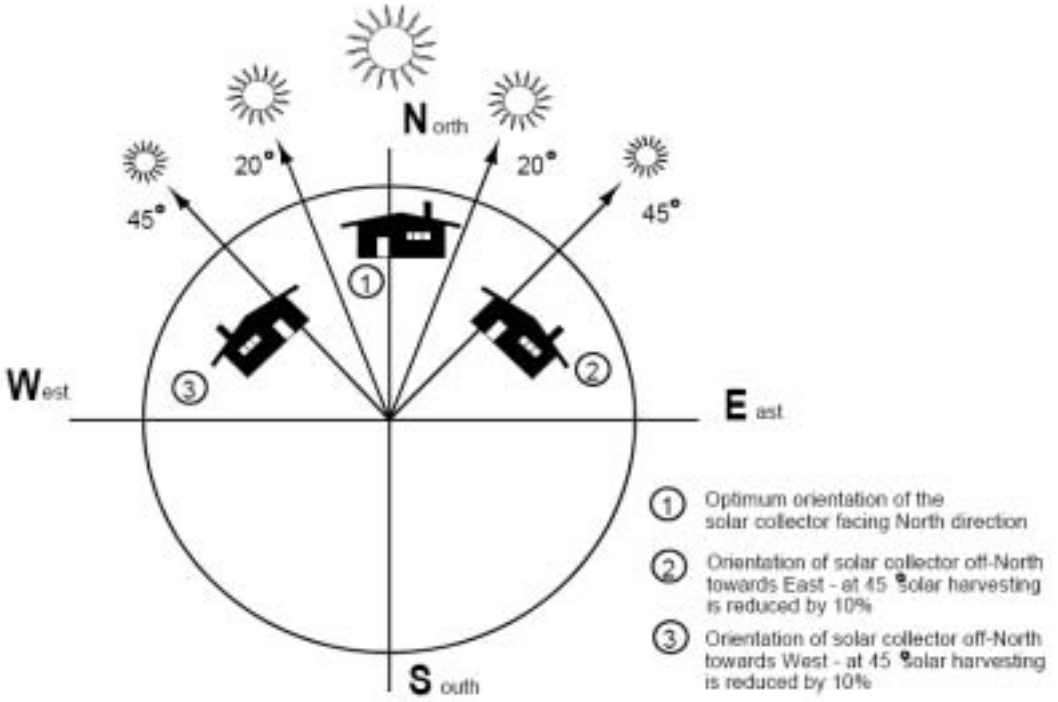
3.3.3.1 Roof

- Determine where the hot water from the SWH system will be used on the premises. Aim at installing the SWH centrally to the points of use to minimise water wastage and heat losses.
- Ideally, the solar collector must be facing true North (remember that true North is approximately 15º East of magnetic North). Orientation of the collectors away from

true North can be as much as 45º if the roof is not north facing, and the SWH system performance will decrease as the deviation increases. Refer to the diagram below (Source: Solahart)

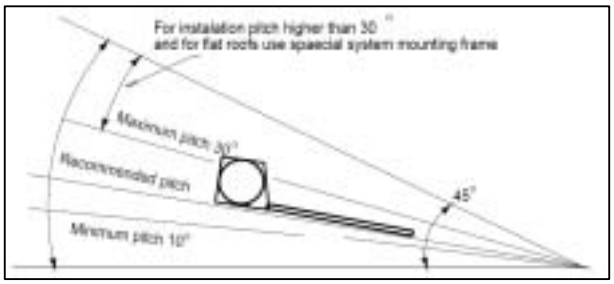


- The solar collectors may be orientated as far as due East or due West. However, in such cases it is advisable to increase the collector area to compensate for the reduced hours of sunshine on the collector. If the household requires hot water by mid-day, then an East orientation should be selected. If the household only really requires hot water in the evening, then a West orientation may be chosen. Refer to Figure below (Source: *Code of Practice for installation, operation, maintenance and repairs of Solar Water Heaters*, South Africa, Final Draft, 2005).

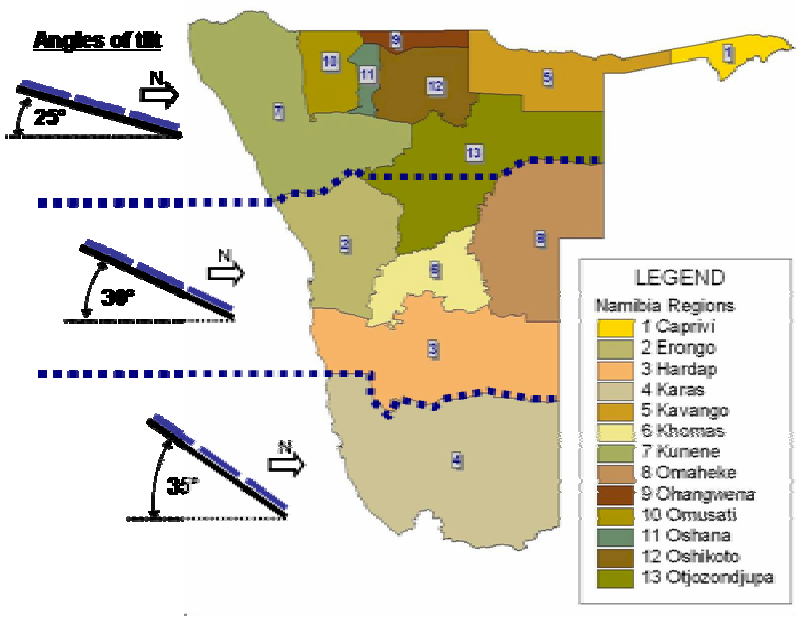


- The pitch (or angle of tilt between the horizontal and the collector) of the SWH should ideally be between equal to the latitude plus ten degrees at the place of installation (e.g. Windhoek 22.5° plus 10°). However, the pitch is not critical for effective

operation. Most manufacturers indicate a minimum angle of about 10° to ensure that the thermosiphon effect can operate. Refer to Figure below (Source: Solahart).

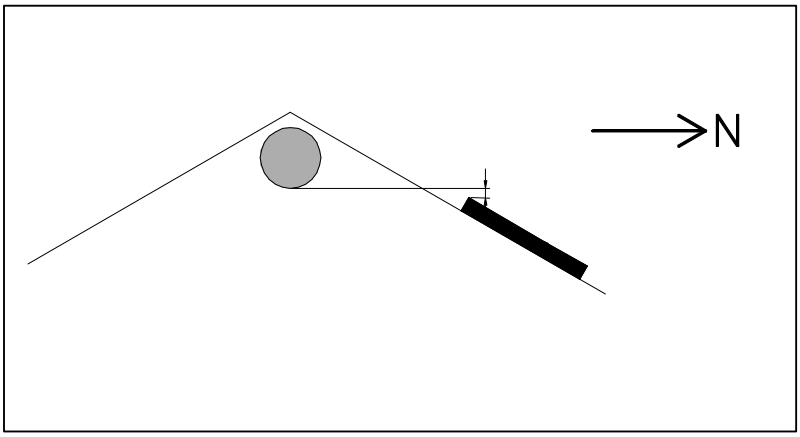

For installation pitch higher than 30 °
and for flat roofs use spaecial system mounting frame
Maximum pitch 30°
Recommended pitch
45°
Minimum pitch 10°

- A rule of thumb for the installation pitch: About 25° in northern Namibia, 30° in central Namibia and 35° in southern Namibia. Refer to the map of Namibia below, showing the different regions.



- The roof pitch will determine the type of stand required to obtain the necessary angle of tilt.
- Identify a place on the roof meeting the above requirements. Ensure that there is enough space for the tank and the collector.
- Ensure that there is no shading along the sun's path from east to west, as well as during summer and winter. In winter the sun's angle is as low as 45º – be sure that there is no or only a minimum of shade from trees, buildings or chimneys.
- Avoid any shading from the hot water tank at the top part of the collector in a close-coupled system; this is particularly relevant during the summer months where the sun is more or less directly above the system at noon.
- Ensure that the supporting roof trusses or the walls underneath the identified place of installation are sufficiently strong to support the weight of the full system. If you are not certain, get professional advice! If necessary, additional support should be provided within the roof to support the SWH system, or a separate support structure must be constructed adjacent to the building.

- If the SWH to be installed is a split system (where the tank is inside the roof space), ensure that the vertical distance between the bottom of the hot water tank and the top of the collector is at least 200mm. Ensure that there is sufficient space in the roof for the tank. The bottom of the tank must be higher than the top of the collector for the natural circulation to work properly. Refer to Figure below (Source: SunTank).



- A thatched roof is normally too steep and the thatch will rot under the system. This type of installation requires a special contractor who can install a special support frame.

3.3.3.2 Water

- Most water in Namibia contains dissolved lime and salts. Total Dissolved Salts (TDS) is a measure of the salt content of water. Water quality differs substantially and can be very localised, but in general water in Namibia has relatively high TDS and is aggressive.
- Lime deposits occur with hard water, and the process is accelerated when water is heated. The use of phosphate dosing (such as microphos) or a water softener installed into the incoming water supply pipeline can reduce this problem.
- One way to ascertain local water quality is to check for lime deposits in electric kettles which have been in use for some time or at taps. If there is concern about water quality, take a water sample to NamWater and have it tested.
- As the water in Namibia generally contains medium to high levels of salts, the use of direct systems is not recommended. Indirect systems are preferred.
- It is important to ensure that the plumbing pipework is sized according to the available pressure to ensure sufficient flow. The water pressure can be tested by inspection or by the use of a pressure gauge. In rural cases the water pressure can be determined by the height of the water storage tank(s). For every 10m of water storage tank height above draw-off point (tap) the pressure will be1 bar = 10m = 100kpa.

3.3.3.3 Climatic conditions

- Frost: An indirect SWH system is required in areas that experience frost. Most of Namibia is a frost area, with the exception of the coastal areas.
- Wind: An installation site where strong wind conditions occur will require extra supports so that the collector can be firmly installed on the roof. Particular care must

be taken when the collectors are installed on a support frame that the collectors and frame are fastened securely to the roof structure.

- Hail: Glazed collectors can be damaged by hail. The glazing should therefore be of a toughened 3mm thick glass which can withstand the most common size of hailstones.

3.3.4 Installation

Make sure that you have all the necessary components of the SWH as well as the pipes and the fittings to be able to complete the installation before going to site.

3.3.4.1 General guidelines

- Use the SWH systems from the Register of Recommended Products.
- Install the system at the place identified during the site assessment (refer to section 3.3.3.1). It should be installed central to where hot water is used, and depend on the roof orientation and installation pitch, consider roof strength for tank and collector, and be in an unshaded position.
- Confirm that there is sufficient access for inspection, maintenance and replacement of components, especially the anode, at the SWH.
- The installation should be neat and secure, and completed according to manufacturer instructions.
- The piping, valves, thermostat and backup element must comply with Namibian standards.
- Make sure that an anode is installed to protect the hot water tank against corrosion, in the case of steel tanks.
- Be sure to use the same or similar metals to avoid corrosion in other parts of the system. Corrosion takes place between dissimilar metal. For this reason, copper and galvanised pipes should never be directly connected to each other, but should have a suitable plastic fitting installed between them.
- The anti-freeze liquid used with an indirect system must be non-hazardous, non-toxic, food-grade anti-freeze with anti-corrosion properties. This fluid is to have a freezing point lower than -10 °C and a boiling point higher than 150°C. Mix one part of anti-freeze to three parts water when filling the collector or follow the instructions of the manufacturer/supplier.
- Refer to the installation manual of the SWH you are installing.

3.3.4.2 Hot Water Storage Tank

- Install and fix the hot water storage tank horizontally on the support frame provided.
- The anode must be accessible for inspection and changing.
- A qualified electrician must install the wiring for the backup element.
- The electrical wiring, which is exposed to the elements, must be weatherproof, and protected against UV. Where the wiring is installed through the roof it must be ensured that the entry point is waterproofed.
- Ensure that the electrical connections are not in contact with any of the water pipes.

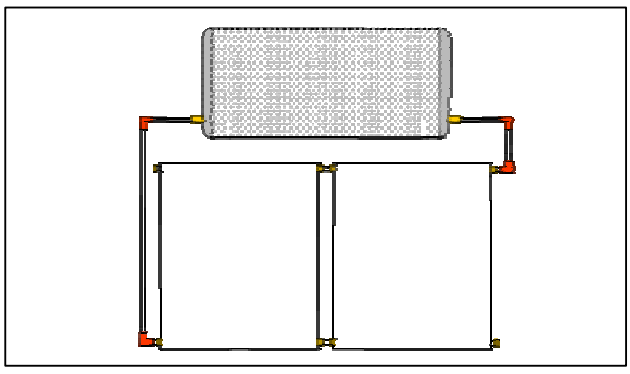
- Waterproof all fasteners that are fitted through the roof.
- In a split system: Provide a drip tray with at least 40mm diameter run-off pipe.
- In a split system where the storage tank is in the ceiling: Provide a drip tray under the tank with at least 40mm diameter run-off pipe.

3.3.4.3 Collector

- The support frame/bracket is to be fixed properly against the roof.
- Place and fix the collectors on the support frame.
- The support frame (if present) must be fixed properly to the roof structure to prevent wind damage, especially to the collectors.
- Be sure that all the air can escape from the collector when being filled. No air should be trapped in the top corner opposite the hot water exit!
- For on roof installations without frame: Seal the gap between the top end of the collector and the roof with flashing to avoid materials collecting underneath the collector (may lead to corrosion on metal roofs due to trapped damp).
- Waterproof all fasteners that are fitted through the roof.
- Ensure that the collector panels are covered to prevent damage prior to commissioning.

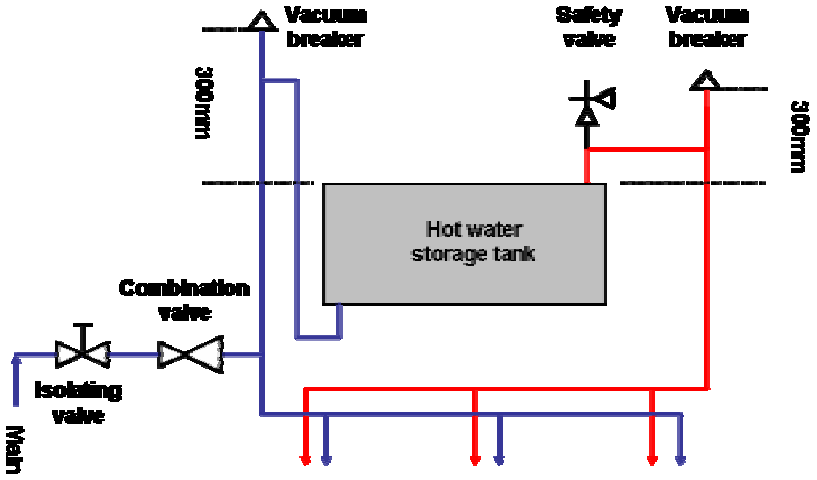
3.3.4.4 Piping

- Connect the collectors to the hot water tank with the pipes and fittings supplied as per manufacturer's specifications. Use PTFE sealing tape or hemp to seal the connection between the fitting and the water tank connection. Note that some manufacturers warn against the use of hemp. Refer to Figure below (Source: SunTank).
- The pipes between the collector and the hot water tank must always be rising (continuous upward slope). Air may not be trapped in the piping as air locks prevent normal thermosiphon flow!



- Be sure that all pipes are fitted in such a way that they do not provide support to the collector or tank! The collector and tank must be held in place by the frame and roof attachment alone.

- All storage tanks have a minimum working pressure rating, generally of 400 kPa. If the Site Assessment (section 3.3.3.2) found that the water pressure is higher than 400kPa, a pressure-regulating valve must be installed into the cold water supply line.
- In general, the following valves are required on the hot and cold plumbing connections to the SWH system (also refer to manufacturer's instructions):
    - Cold Supply: Isolating valve (Ball valve); combination pressure, non-return and expansion valve, vacuum breaker at least 300mm above top of tank.
    - Hot Supply: Safety valve (Pressure & temperature relief valve); vacuum breaker at least 300mm above top of tank
- Drain connection piping from the combination valve and the safety valve must be piped down to ground level. Drain points should not discharge onto the roof as it leaves lime deposits and can result in corrosion damage.

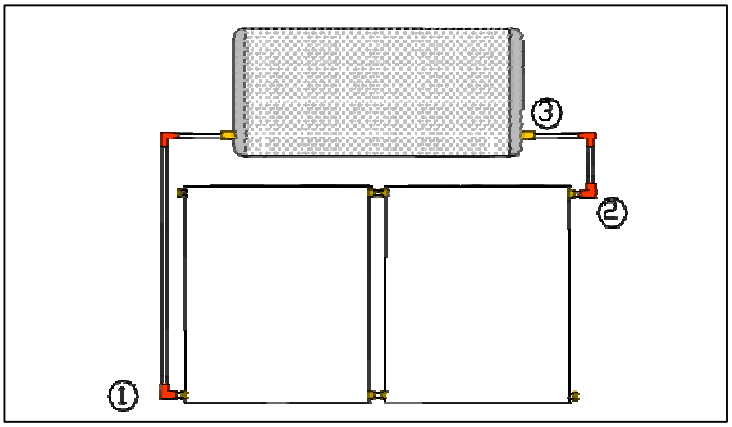


- All exposed plumbing pipes above the roof must be insulated. This includes cold and hot water pipes and the pipes connecting collectors to the tank. Place UV protection around the insulation.
- Waterproof all pipes that are fitted through the roof with a good quality membrane sealant or equivalent.
- For all of the installation work observe building and plumbing codes.

3.3.4.5 Filling an indirect Solar Water Heater system

1. Fill the hot water tank by opening the cold water supply. Remove the air from the system by opening the hot water outlet. When the tank is full, close the hot water tap and check for any leakage.
    a. ALWAYS FILL THE STORAGE TANK BEFORE FILLING COLLECTORS.
    b. ALWAYS ENSURE THAT THE COLLECTORS ARE COVERED SO THAT THEY ARE FULLY SHADED PRIOR TO COMMISSIONING.
    c. KEEP THE BACKUP ELECTRICAL ELEMENT SWITCHED OFF DURING COMMISSIONING.
2. Fill the anti-freeze liquid slowly into the collector according to the manufacturer's installation instructions. The fluid is generally filled through the filling point or at the bottom entry (cold in) until full. Allow air to escape from the system and repeat until mixture level is stable and no air bubbles are visible before closing filling point.

3. Note that some manufacturers require that pressure is applied to the closed circuit.
4. Remove the shading of the collectors. With sun on the collector perform a circulation test. After a few minutes the bottom inlet pipe to the collector should be cool, while the top pipe connected to the collector should be hot, both at the collector and at the connection to the storage tank. Refer to Figure below (Source: SunTank): Point 1 - cold, Point 2 - hot, Point 3 - hot.



3.3.5 Commissioning

Commissioning is the procedure by which the installed SWH system is tested and certified to be in fully operational condition. Commissioning is a very important step as it can show where mistakes have been made during the installation. Finding and resolving a mistake at this stage often saves another trip to the site in future.

Commission the installed system as follows:

- As the system starts to operate (assuming sufficient solar irradiation), check the system for any leaks.
- Test if there is a heat difference between the cold water supply to the solar collector and the hot water supply from the collector after an hour or more.
- If possible check that the system is working properly either later during the installation day or on the following day. Hand test the top hot outlet against bottom cold inlet after a few hours of operation.
- Confirm that the electrical backup element is working (electricity meter or clamp-on meter).
- Any damage to the roof or building caused by the installation must be made good.

3.3.6 Hand-over to customer

During the hand-over of the system to the customer, the installer has the duty to:

- Explain the basic operation of the SWH.
- Explain the system's daily hot water delivery capacity.
- Explain how the system can be expanded in future.
- Provide system documentation:

  - SWH manual.
  - Complete the installation record noting component details and serial numbers.
  - Leave any documents that are specific to the system with the customer (for example for the electrical backup element).
  - The warranty documentation provided by the supplier/manufacturer.
- Explain what maintenance tasks have to be performed by the customer:
  - Clean the collector glass once every six months, especially during winter months or periods of no or little rain.
  - Check and remove any shade from the collector (tree branches).
- Explain to the customer that you will return for two maintenance and inspection visits after one year and after two years and what your duties will be.
- Provide contact details of service provider: provide the customer with your own contact details, and those of the SWH supplier.
- Explain Warranty conditions: consult SWH supplier beforehand, and provide the customer with a written guarantee for the system and installation
- Advise the customer that they should contact their insurance agent to check whether the SWH is included in their insurance cover.

If for some reason the system is not complete (e.g. booster element was not available) then inform the customer about this and agree on when the remaining items will be delivered and installed.

3.3.7 Maintenance

The maintenance tasks described here refer to the maintenance items that the solar technician needs to perform after the system has been in operation for 3-5 years, depending on water quality and depending on manufacturer's instructions:

- Checking the heat exchange fluid in an indirect system: It is recommended to check and top-up the fluid if necessary.
- Replacing the heat exchange fluid in an indirect system: It is recommended to replace the fluid every 3 to 5 years.
- Replacing the anode: Depending on the water quality, the anode needs to be checked and if necessary replaced every 3-5 years..
- Replace PT safety valve.
- Flush cold water relief valve.
- Check element, replace if necessary.
- Check thermostat, replace if necessary.
- Check for physical damage. (dust, leaks, shading)
- Drain and flush out sediment from the storage tank.
- Clean collector glass.

4 RECOMMENDATIONS

The Register of Recommended Products has been well received at the workshop and during individual stakeholder interaction. It is recommended to distribute the first Register of Recommended Products as soon as possible and meeting with Konga Investments to encourage the adoption thereof.

It is recommended to look into ways of integrating the Products Register into the SRF loan application form, without making it part of the document, since it will be changing a number of times per year. Perhaps it can be attached as a loose sheet to the application form.

Since NAMREP is at this stage the renewable energy portal in Namibia, it is recommended that NAMREP initiates the forming of the Products Evaluation Panel until this can be handed over to the REEE Institute.

It is recommended that a professional graphic designer improves the layout and the graphics of the Codes of Practice and reformats the document into an A5 format brochure. There is a need to develop a common style and notation for these Codes. The Team has for example intentionally used the bullet form and short sentences to make the Code accessible – that can possibly be enhanced in the version going to the printers.

The current outline level reaches five levels (e.g. heading number 3.2.4.2.1) for the purpose of this report. When the Codes are reformatted the level of the outline numbering can be reduced by two levels (e.g. to heading number 4.2.1).

The Codes can make use of appendices for some of the repetitive information such as cable diameters.

As another enhancement suppliers of the various products should be given the opportunity to provide inserts for the booklet (not bound as part of the booklet) which list special tips for the technology which the supplier provides. This may be especially useful for PVP and SWH.

5 REFERENCES

GENERAL

Atlas of Namibia – A Portrait of the Land and its People, John Mendelsohn, Alice Jarvis, Carole Roberts and Tony Robertson, Published for the Ministry of Environment and Tourism of Namibia by David Philip, 2002.

A Solar Radiation Data Handbook for Southern Africa, Anton A Eberhard, 1990.

SOLAR HOME SYSTEMS

Code of Practice, Southern African Solar Module Suppliers Association, consisting of Grinaker System Technologies, Helios Power and Siemens Ltd, 1994.

Code of Practice for installing low-voltage PV power systems, Energy for Development Research Centre, University of Cape Town, South Africa; for Department of Mineral and Energy, 1996.

Code of Practice – Photovoltaic Energy Installations in Botswana, Botswana Technology Centre, Gaborone, Botswana; in collaboration with Ministry of Mineral Resources and Water Affairs, 1993.

Universal Technical Standard for Solar Home Systems, Thermie B SUP 995-96, EC-DGXVII, 1998.

SOLAR PV WATER PUMPING

Solar Pumping for Communities – Technical Manual, Energy for Development Group for Department of Water Affairs and Forestry, Cape Town, South Africa, April 2001.

Photovoltaic Pump Handbook, Mark Davis, Energy for Development Research Centre, University of Cape Town, South Africa, 1993.

SOLAR WATER HEATERS

Code of Practice for installation, operation, maintenance and repairs of Solar Water Heaters, South Africa, Final Draft (no other references provided), 2005.

Code of Practice for domestic Solar Water Heaters in Botswana, Energy Affairs Division, Ministry of Mineral Resources and Water Affairs, Botswana, March 1993.

Code of Practice for Manufacture and Installation of Solar Water Heating Systems in New Zealand, Solar Industries Association, Version: 1 October 2004 (Revision 3), Wellington, New Zealand.

Annexure

A1 Evaluation of SHS Components

Table A 1: Solar PV modules

Solar PV modules	Cell type	№ of cells	IEC 61215/ IEC 61464	UL/ISPRA certified	Power warranty [years]	Framed	Passed
Criteria		36	Either	Or	20	Yes	
BP Solar, amorphous, 10W/20Wpeak	a-Si	n/a	Yes	n/a	10	Yes	Yes
BP Solar, amorphous, 43W/50Wpeak	a-Si	n/a	Yes	n/a	20	Yes	Yes
BP Solar, mono, 50/70/75/80Wpeak	mono	36	Yes	Yes	20	Yes	Yes
BP Solar, poly, 5/10/20/40/50/65Wpeak	poly	36	Yes	Yes	12	Yes	Yes
BP Solar, poly, 60/80/125Wpeak	poly	36	Yes	Yes	25	Yes	Yes
Kyocera, poly, 40 to 130Wpeak	poly	36	Yes	Yes	25	Yes	Yes
Sanyo, HIT, 56/62Wpeak	HIT	36	Yes	Yes	20	Yes	Yes
Sharp, poly, 80/125Wpeak	poly	36	No	Yes	25	Yes	Yes
Shell Solar (Solar World), CIS, 10 Wpeak	CIS	n/a	Yes	No	10	Yes	Yes
Shell Solar (Solar World), CIS, 20/40/80 Wpeak	CIS	n/a	Yes	No	10	Yes	No
Shell Solar (Solar World), mono, 20 to 50Wpeak	mono	36	Yes	No	20	Yes	Yes
Shell Solar (Solar World), mono, 80/85Wpeak	mono	36	Yes	No	25	Yes	Yes
Solara S Series, 50/125Wpeak		36	Yes	No	26	Yes	Yes
Sunset, mono, 65/80Wpeak	mono	36	Yes	No	25	Yes	Yes
Total Energie/Tenesa, mono, 120 to 140 Wpeak	mono	36	Yes	Yes	20	Yes	Yes
Total Energie/Tenesa, poly, 50 to 140 Wpeak	poly	36	Yes	No	25	Yes	Yes

Table A 2: Batteries

Batteries	Nominal Ah [Ah]	Rated at [C value]	Cycles [cycles]	@ DOD [%]	Warranty [years]	Passed
Criteria			800	10%	1	
Raylite, Leisure RR1, 12V, 60Ah (C20)	60	C20	1,000	20%	1	Yes
Raylite, Leisure RR2, 12V, 96Ah (C20)	96	C20	1,000	20%	1	Yes
Willard, Leisure 774, 12V, 90Ah (C20)	90	C20	800	10%	1	Yes
Willard, Solar 105, 12V, 105 Ah (C100)	95	C20	800	10%	1	Yes
Willard MT range, 2V, 240 to 720Ah (C100)		C100	3,450	20%	1	Yes
Willard RT range, 2V, 290 to 880Ah (C100)		C100	3,450	20%	1	Yes

Table A 3: Charge controllers

Charge controllers	Regulation type	Voltage	Solid state	Charging algorithm	Temperature compensation	Self consumption less than 10mA	Electronic protection	Fuse element	Indicators	Lightning surge protection	Warranty	Passed
		[V]				[mA]					[years]	
Criteria			Solid-state	Boost & Float	Yes	< 10mA	Yes		Yes	Yes	2	
Engineerging Centre, EcSAT range, 12/24V, 10A, series	Series	12 & 24	Yes	Yes	Yes	8	Yes	No	Yes	Yes	2	Yes
Morningstar, Sunsaver range, 12V, 6/10/20A	Series	12	Yes	Yes	Yes	6-10	Yes	No	Yes	Yes	5	Yes
Phocos, CML range, 12/24V, 5/10/15/20A, series	Series	12 & 24	Yes	Yes	Yes	4	Yes	No	Yes	Yes	2	Yes
Phocos, CX range, 12/24V, 8/16/32A, series	Series	12 & 24	Yes	Yes	Yes	4	Yes	No	Yes	Yes	2	Yes
Steca, PR range, 12/24V, 10/15/20/30A, shunt	Shunt	12 & 24	Yes	Yes	Yes	12	Yes	No	Yes	Yes	2	Yes
Steca, PR range, 12V, 3/5A, series	Series	12	Yes	Yes	Yes	3	Yes	No	Yes	Yes	2	Yes
Steca, Solarix range, 12/24V, 8/12/20/30A, shunt	Shunt	12 & 24	Yes	Yes	Yes	5	Yes	Integrated	Yes	Yes	2	Yes
Steca, Solsum range, 12/24V, 6/8/10A, shunt	Shunt	12 & 24	Yes	Yes	Yes	4	Yes	Integrated	Yes	Yes	2	Yes

Note: The Steca PR charge controller has been passed since it adds the feature of a user interface, which is also the reason that the self-consumption is higher than average.

Table A 4: Lamps

Lamps	CFL or LED	Nominal power range of series	Lumens	Nominal Voltage	Voltage range	Expected operating hours	Switching cycles	Internal fuse protection	Reverse polarity protection	Passed
		[W]	[W/m²]	[V]	[V]	[hours]	[cycles]			
Criteria				12	11-15	3,000	40,000	Yes	Yes	
[Eurolux]	CFL			12						No
Phocos, CLI range, 12V, 15/30W	CFL	15 & 30	50	12	11 to 15	10,000	100,000	Yes	Yes	Yes
Phocos, CLI range, 12V, 5/7/11W	CFL	5, 7 & 11	46	12	11 to 15	10,000	100,000	Yes	Yes	Yes
Phocos, SLI range, 12V, 0.4/1.2W	LED	0.4 & 1.2	16 to 20	12	11 to 15	100,000	n/a	Yes	Yes	Yes
Steca, SolLed range, 12V, 0.35/0.7W	LED	0.35 & 0.7	16 to 22	12	11 to 15	100,000	n/a	Yes	Yes	Yes
Steca, Solsum range, 12V, 5/7/11W	CFL	5, 7 & 11	42 to 50	12	11 to 15	6,000	100,000	Yes	Yes	Yes
Steca, ULed range, 12V, 0.9/1.2/1.5W	LED	0.9, 1.2 & 1.5	188 to 22	12	11 to 15	50,000	n/a	Yes	Yes	Yes

Table A 5: Inverters

Inverters	Sine-wave	Surge power	No-load power	Electronic overload - not fuse	Low-voltage shut-down	Warranty	Passed
		[%]	[%]			[years]	
Criteria	Yes	> 150%	< 1.5%	Yes	Yes	1	
ASP, 12V, 150VA	Yes	250%	1.33%	Yes	Yes	1	Yes
Studer, 12V, 200/400VA	Yes	225%	0.95%	Yes	Yes	1	Yes
Sunset, 12V, 400/600/800W	Yes	200%	0.60%	Yes	Yes	1	Yes
Victron, 12V, 180/350/650VA	Yes	120%	1.20%	Yes	Yes	1	Yes

A2 Evaluation of Photovoltaic Pumping Products

Table A 6: Solar PV modules

Solar PV modules	Cell type	№ of cells	IEC 61215/ IEC 61464	UL/ISPRA certified	Power warranty	Framed	Passed
					[years]		
Criteria		36	Either	Or	20	Yes	
All modules listed under SHS as well as:							
BP Solar, mono, 140/150Wpeak	mono	72	Yes	Yes	25	Yes	Yes
BP Solar, poly, 110/120/1140/150Wpeak	poly	72	Yes	Yes	25	Yes	Yes
Kyocera, poly, 158 to 200Wpeak	poly	48+	Yes	Yes	25	Yes	Yes
Sanyo, HIT, 200/205/210Wpeak	HIT	72+	Yes	Yes	20	Yes	Yes
Sharp, mono, 175/180/185Wpeak	mono	48+	No	Yes	25	Yes	Yes
Sharp, poly, 140 to 200Wpeak	poly	48+	No	Yes	25	Yes	Yes
Shell Solar (Solar World), poly, 150/160Wpeak	poly	72	Yes	No	20	Yes	Yes
Sunset, mono, 110 to 170Wpeak	mono	54+	Yes	No	25	Yes	Yes
Total Energie/Tenesa, mono, 190 to 210 Wpeak	mono	54+	Yes	No	25	Yes	Yes
Total Energie/Tenesa, poly, 160 to 210 Wpeak	poly	54+	Yes	No	25	Yes	Yes

Table A 7: Pump subsystem

Pumping subset	Maximum depth	Maximum volume flow	Hydraulic head	Warranty on pumpset	Protection of controller	Dry-run protection on centrifugal	Status indicators	Corrosion resistance of submersible pump	Passed
	[m]	[m³/h]	[m^4/h]	[years]					
Criteria				1	Short-circuit; Over-load	Yes	Yes	Stainless steel; bronze, PVC	
Grundfos, SQFlex, centrifugal, 30m head	30	14		1	Yes	Yes	Yes	Yes	Yes
Grundfos, SQFlex, helical rotor, 120m head	120	2.5		1	Yes	n/a	Yes	Yes	Yes
Juwa, 200m head	200			1	Yes	Yes	?	Yes	Yes
Lorentz, centrifugal, 30m head max	30	18	130	1	Yes	Yes	Yes	Yes	Yes
Lorentz, helical rotor, 240m head max	240	4	100	1	Yes	n/a	Yes	Yes	Yes
Shurflo, Series 9300, 70m head	70	0.4	21	1	Yes	n/a	Yes	Yes	Yes
Solastar, diaghragm pump				1	Yes	n/a	Yes	Yes	Yes
WaterMax, diaphragm pump, 150m head max	150	0.85		1	Yes	n/a	Yes	Yes	Yes

A3 Evaluation of Solar Water Heater Products

Table A 8: Solar Water Heaters I

Solar Water Heaters	Type	Operation	Back-up element	Warranty	Collector glass thickness	Collector casing	Collector absorber	Collector pressure rating
Criteria	Indirect (=Closed circuit)	Natural thermosyphon	Yes	5 years minimum	min. 3mm thick tempered glass	Mild steel/ aluminium	Aluminium,copper or steel with heat absorbing coating	Min 425kPa
Chromagen	Indirect	Thermosyphon	Yes	5 years tank, 10 years collector	3.2mm low iron tempered solar glass	Aluminium	Copper fins on plate with black chrome on nickel coating	1,000 kPa
Megasun	Indirect	Thermosyphon	Yes	10 years	3.5mm solar tempered glass	Aluminium	Copper	2080 kPa
Solahart	Indirect	Thermosyphon	Yes	5 years	3.2mm low iron tempered solar glass	Aluminium	Mild steel, black chrome coating	450 kPA
Solardome Sunstor	Indirect	Thermosyphon	Yes	5 years	4mm tempered toughened glass	Anodised Aluminium and hot dipped galvanised 0.5mm sheet backing	Aluminium plate with 15mm copper risers and 22mm copper headers, with spray applied absorbtion coating	900 kPA working pressure
SunTank	Indirect	Thermosyphon	Yes	5 years	4mm hail resistant glass	Aluminium frame with PVC base	8x15mm copper tubes with 22mm manifold, aluminium plate with heat absorbing coating	800 kPa
Xstream Solarstream	Indirect	Thermosyphon	Yes	5 years on tank, 3 years on panels	4mm tempered transparent glass	Aluminium frame with 0.5mm galvanised sheet back	Aluminium/copper fin and tube with black anodising	800 kPa
K & K Solar	Direct							

Table A 9: Solar Water Heaters II

Solar Water Heaters	Storage tank test pressure rating	Storage tank working pressure	Storage tank outer casing	Storage tank insulation material	Storage tank cylinder material	Sacrificial anode	Passed
Criteria	2,000 kPa	Min. 400kPa	Aluminium or steel with corrosion protection	CFC free insulation (e.g. Polyurethane)	Steel or stainless steel with sacrificial anode, Epoxy vinyl ester, copper, brass	Sacrificial magnesium anode	
Chromagen	1,500 kPa	800 kPa	Stainless steel or white polyester	30mm Polyurethane	3mm thick steel with glass-enamel layer	Yes	YES
Megasun	2,080 kPa	1,000 kPa	Anodised aluminium	50mm high density Polyurethane	4mm galvanised mild steel coated with Durosmalt enamel coating.	Yes	YES
Solahart	2,100 kPa	1,000 kPa	Aluminium	Polyurethane	2.5mmm mild steel with 0.3mm vireous enamel ceramic lining	Yes	YES
Solardome Sunstor	600 kPa	400kPa	0.7mm Grade 5251 Aluminium	1.6mm cork barrier + Polystyrene granules + high density polystyrene	Copper	Not required	YES
SunTank	800 kPa	400kPa	Stainless steel & ends of fibreglass on polyurethane	High density Polyurethane	1.6mm stainless steel 1435 grade	Yes	YES
Xstream Solarstream	1,600 kPa	400 kPa	UV Stabilised glass reinforced gelcoat, 3mm	High density Polyurethane	Derakane Epoxy Vinyl Ester	Not required	YES
K & K Solar							No

A4 Stakeholders

NOTE: List here whose products are reflected, who was contacted for inputs to the products criteria and who gave input to the Code of Practice (which may come more out of the workshop).

The following Solar Energy Technology providers were contacted during the course of this project:

SET provider	Contacted?	Response	SHS	PVP	SWH
ConServ	Y (t/e)	Y/Y	X	X	X
Engineering Centre	Y (t)	Y	X		
E-Power	Y (e)	Y		X	
Excelsior	Y (t/e)	Y/N		X	X
HPS Engineering	Y (e)	Y	X	X	X
Industrial Control & Engineering	Y (t/e)	Y/N	X		
K&K Solar	Y (e)	N			X
MEC Technology	Y (t/e)	Y/Y	X		
NEC	Y (e)	Y	X	X	X
Pupkewitz MegaTech	Y (t)	Y			X
Renewable Energy Solutions	Y (e)	Y	X		
Siemens	Y (t)	Y	X		
SK Holdings	Y (t/e)	Y/N	X	?	?
Solar Age Namibia	Y (e)	Y	X	X	X
SolTec	Y (v)	Y	X	X	X
SunTank Namibia	Y (e)	Y			X
TerraSol	Y (t)	Y		X	
Tjamburo, P	Y (t)	Y	X	X	X
Willard	Y (t)	Y	X		

t – telephone call; e - email

A1.1 REGISTER OF RECOMMENDED PRODUCTS

A1.1.1 Solar Home Systems

The following stakeholders were contacted for their SHS products. The product is listed under the principal importer for the particular product, although it may be traded by a number of the stakeholders listed:

Table: Suppliers of Solar Home System Products

Supplier	Solar PV modules	Batteries	Charge controllers	Lamps	Inverters
ConServ	Sunset		Sunset (Steca)		Sunset ASP
Engineering Centre		Raylite	EC		
Industrial Control & Engineering	Sanyo				
MEC Technology	Solara		Phocos	Phocos	Studer
Radio Electronic					Victron
Siemens	Shell		Steca		
SK Holdings	Neste?				
Solar Age Namibia			Phocos	Phocos	
SolTec	Sanyo		Steca	Eurolux	
Willard	Total Energie	Willard	Morningstar		

A1.1.2 PV Water Pumps

The following stakeholders were contacted for their PVP products. The product is listed under the principal importer for the particular product, although it may be traded by a number of the stakeholders listed:

Table: Suppliers of Solar PV Water Pumping Systems

Supplier	Solar PV modules	Pumping subset
ConServ	Sunset	Grundfos
Solar Age		Shurflo
SolTec	Sanyo	Shurflo, Lorentz, Shurflo, Solastar, All Power
NEC	BP Solar	Grundfos
Terrasol	Kyocera, Sharp	Lorentz, Juwa

A1.1.3 Solar Water Heaters

The following stakeholders were contacted for their SWH products. The product is listed under the principal importer for the particular product, although it may be traded by a number of the stakeholders listed:

Table: Suppliers of Solar Water Heater Systems

Supplier	SWH
ConServ	Chromargan
Excelsior	Megasun
K&K Solar	K&K
NEC	Solahart
Pupkewitz MegaTech	Xstream
SolTec	Solardome
SunTank	SunTank

A5 Workshop proceedings

Product Evaluation Guide and Code of Practice for Solar Energy Technologies Workshop

held

19 April 2006

Windhoek

WORKSHOP PROCEEDINGS

1. Presentations

The workshop was facilitated by Mr Martin Heita. Mr Heita opened the workshop giving perspective on some international developments in the renewable energy and energy efficiency sector and provided an overview of the activities that the Namibia Renewable Energy Programme (NAMREP) is conducting locally in Namibia. The Product Guide and Code of Practice Project initiated by NAMREP aims to provide guidance to solar suppliers, solar technicians, administrators of the Solar Revolving Fund and the solar customers at large. Mr Heita reiterated that the project is not an attempt to influence free market enterprise, but that solar energy suppliers and technicians have a responsibility towards their clients. The project will ease the adoption of this responsibility by introducing product recommendations and regulation, specifically in regard to the Solar Revolving Fund.

Mr Axel Scholle presented the workshop presentation and stressed that the product guidelines and the code of practice apply only to Solar Home Systems (SHS), Solar water Pumps (PVP) and Solar Water Heaters (SWH) and should not be viewed as a fixed recommendation. Both the product guide and code of practice will be reviewed and updated regularly.

Mr Glenn Howard supplemented Mr Scholle's presentation with details about the product guide and code of practice for SWH.

2. Discussion

The workshop initiated a lengthy discussion with participants in order to ascertain concerns about the contents of the Product Guide and Code of Practice, respond to queries and gather recommendations.

Queries and responses are printed below:

2.1. General

What is the purpose of a Product Guide?

- The Product Guide will apply only to the Solar Revolving Fund and possibly other Government of Namibia initiated funding schemes for solar energy technologies. Suppliers may offer stipulated products only. This will ensure optimal service life of the supplied solar technologies and prevent public funds from being abused by short-term profiteering. The Product Guide should also serve to assure and inform customers of solar technologies of product quality. This will instil long-term confidence in renewable energy products.

Should solar technicians not be trained to also install SWH and PVP?

- This is encouraged and NAMREP has already initiated training solar technicians on the other solar technologies, while also training Vocational Training Centres to include the three solar technologies into their training curriculum.

Can solar technicians be encouraged to share their experiences from the field?

- Efforts, such as this workshop, offer a platform for solar technicians to contribute openly to the solar energy technology discussion. It is vital that solar technicians become more active in the selection of technologies.

How will the Product Guide be enforced?

- Suppliers of solar energy technologies who submit quotations to the Solar Revolving Fund are required to clearly specify the components used in both the Quotation and the Invoice. Administrators of the fund can then verify that recommended products are used, which should lead to greater customer satisfaction and ensure uninterrupted repayments of loans. This is vital to the sustainability of the fund.
- Suppliers are however at liberty to provide any components to customers who are not making use of the Solar Revolving.

How will the Product Guide and Code of Practice be updated?

- NAMREP will initiate the establishment of an independent Advisory Panel under chairmanship of the Ministry of Mines and Energy. This Panel will meet regularly to review applications for new products and will amend the Product Guide as required.
- Suppliers and solar technicians can submit the specifications of new products to MME / NAMREP for review by the Advisory Panel.

2.2. Solar Home Systems (SHS)

Why is a 20-year warranty for photo-voltaic (PV) modules specified?

- After discussions regarding the advantages and disadvantages of this specification, a recommendation was made to state "a warranty of 10 years and beyond".

Does the warranty include theft?

- Theft is not included in the warranty. Theft is an insurance issue. The Solar Revolving Fund includes insurance on solar energy products against "Acts of God", but theft is specifically excluded.
- Customers must be properly informed that their systems are not insured against theft and that they should take adequate precautions to minimise risk.

Why are gel-type batteries and low wattage PV modules not recommended?

- Gel-type batteries and low wattage PV modules are suitable for small-size SHS and these are generally not supplied through the Solar Revolving Fund.

Should 220 Volt Compact Fluorescent Lights be included?

- This will be considered

Why are the Willard batteries only provisionally included?

- Specifications by the manufacturer do not meet the minimum requirements. However, the batteries have performed well in the field. This discrepancy might be due to the fact that the batteries are under-specified.

Are low maintenance sealed batteries encouraged?

- No recommendation to that effect has been made. Both batteries that are "low maintenance" and those that require periodic refilling with distilled water have merits and limitations

Why are cheaper stepped-square wave inverters not recommended?

- Stepped-square wave inverters are problematic for certain appliances. The use of appliances by customers cannot be controlled and unsuitable appliances may result in failure of the appliance.
- Sine wave inverters are more stable, readily available and less of a risk.

Can the following solar components be considered for recommendation in the Product Guide?

1. Delco Battery (from ElectroTech)
2. Eurolux Compact Fluorescent Lights
3. M-Solar deep-cycle Battery

- This will be considered.

2.3. Solar Water Heaters (SWH)

Why are only close-coupled (indirect) SWH recommended?

- Open (direct) SWH have resulted in a negative reputation for SWH. Although some of the shortcomings have been resolved in recent years, the direct SWH remains vulnerable to aggressive waters and frost. In terms of the Solar Revolving Fund, it was decided to avoid risk and only to recommend indirect systems.
- Indirect SWH also generally offer a longer warranty than direct SWH.
- The inclusion of direct SWH can be considered in the future, particularly for certain applications such as space heating and larger institutional systems.

2.4. Photovoltaic Pumps (PVP)

Why is the Namibian-made JUWA solar pump and mono-type solar pumps not included?

- Focus was on submersible-type PVPs, since there are less technically complex to install. This is especially a consideration for solar technicians. The Code of Practice is thus only based on submersible-type PVPs.
- However, the JUWA should be included under the Solar Revolving Fund as it has already been sold through the fund.

3. Participants

NAMREP: Recommended Products and Content of Code of Practice

List of Participants

Workshop, 19 April 2006, 10:00 to 13:00, Habitat Centre

Proposed stakeholders

	Stakeholder	Sector	Email	Tel
1	Hamutwe-Jr, Shimweelelasi G	NAMREP	ghamutwe@mme.gov.na	(061) 284 8169
2	Hasheela, Raino	NAMREP	rhasheela@mme.gov.na	(061) 284 8170
3	Hipangelwa, Noddy	MME	nhipangelwa@mme.gov.na	(061) 284 8205
4	Kalompo, Loide	Kanga Investment	kanga@mweb.com.na	(061) 259 961
5	Clarke, Gerrit	Electricity Control Board	gclarke@ecb.org.na	(061) 374 309
6	Nakatana, Leevi	Windhoek Vocational Training Centre	nakatana@wvtc.edu.na	061-21 1742
7	Kaakunga, Rijandja Ali	Namibia Standards Information & Quality Office	kaakunga@nsi.gov.na	(061) 283 7271/3
8	van den Heever, Sean	RE Technicians Association		081 1228740/081 2771280
9	Tjambiru, Prescott	Solar Technician		081 128 7168
10	Nyambali, Mateus	Solar Technician		081 243 2192
11	Hailume, Polly	Solar Technician		081 122 3802 / 081 272 5776
12	Ngololo, Johannes	Solar Technician		081 257 6633
13	Namachila, Sackarias	Solar Technician		(061) 208 7043 / 081 256 5008
14	Sackaria, Leonard	Solar Technician	nangsacky@yahoo.com.na	081 280 9497 / 081 129 6065
15	Shikokola, Letisia	Solar Technician		081 2893206
16	Khachab, Richard	Solar Technician		081 242 2826
17	Kauaria, Tjaa	Solar Technician		081 2536 186
18	Awene, Albert	MEC Technology	mec@iway.na	081 122 1711
19	Brückner, Niko	NEC	nbrueckner@namencar.com.na	(061) 236 720
20	Roedern, Conrad	Solar Age Namibia	roedern@iafrica.com.na	(061) 215 809
21	Steuber, Heinrich	SolTec	h.steuber@soltec.com.na	(061) 235 646
22	Schultz, Werner	TerraSol	terrasol@iafrica.com.na	(061) 239 454
23	Abrahams, Leonard	Siemens	leonard.abrahams@siemens.com	(061) 278 700
24	Snyman, Hanno	Willard Batteries	hsnyman@willard.co.za	(061) 234 023
25	Gessow, Klaas	Radio Electronics	rec@mcc.com.na	(061) 258 231
26	Sieler, Joern	Engineering Centre	ecentre@mweb.com.na	(061) 220 696
27	Mathew-Uunona, Catherine	Solar Technician	catherinem@cca.com.na	061-237427
28	Shiyagaya, Absai	Solar Technician		81 1246969
29	Robert Schultz	DRFN		061-269222
30	Nguvo Jackson	Solar Technician		81 1296337

End of Document

A6 Terms of Reference

NAMIBIA

MINISTRY OF MINES AND ENERGY

PROJECT MANAGEMENT UNIT

UNDP/GEF/MME Barrier Removal to Namibian Renewable Energy Programme (NAMREP)
P/Bag 13297 Windhoek Namibia Tel 061 284 8111 Fax 061 284 8173

Invitation of Bids for Developing Recommended Products Lists and Code of Practice for Solar Energy Technologies

Terms of Reference – Revision 1

1. PROJECT BACKGROUND

Namibia has one of the most favorable solar regimes in the world and a supportive renewable energy policy. The country has the possibility to create a small yet efficient market for renewable energy technologies. However, there are a number of barriers that impede the increased utilization of solar energy. These can be classified into five categories: capacity, institutional, financial, awareness and technical. The Namibian Renewable Energy Programme (NAMREP) intends to remove these market barriers and facilitate in implementing the Namibian Ministry of Mines and Energy (MME) White Paper strategy for Renewable Energy: *"Government will promote the use of renewable energy through the establishment of an adequate institutional and planning framework, the development of human resources and public awareness and suitable financing systems. It also seeks to meet development challenges through improved access to renewable energy sources, particularly in rural electrification, rural water supply and solar housing and water heating".*

The **development objective** of the NAMREP Project is to increase affordable access to sustainable energy services through the further development of a market for Renewable Energy Technologies (RETs) in Namibia that contribute to climate stabilization by reducing CO_2 emissions through the removal of technical, financial, social, institutional, capacity, public awareness and social acceptability barriers.

The **immediate objective** is to remove barriers to the delivery of commercially, institutionally, and technically sustainable RES including electricity production (for off-grid lighting, radio, TV, water pumping, and refrigeration), and water heating to the household, institutional, commercial, and agro-industrial sectors and to demonstrate the enabled environment through affirming demonstrations of the applications of the technologies. The Project has the following six components as focus areas barrier removal:

1 **Component 1: Capacity building:** the capacity building component will focus amongst others on the training of Private Sector (PV industry), the NGOs staff, the Government and the PMU to create technical capacity in dealing with renewable energy issues.

1 **Component 2: Removal of institutional barriers:** the primary objective of this component is to influence GRN institutional policies so as to make them more favourable/equitable to RETs. This will be achieved through removing budgeting, subsidies, information and other institutional barriers to the appropriate use of RESs in planning processes at inter-sectoral levels.

2 **Component 3: Public awareness and social acceptability:** the overriding cross technology awareness building and social acceptability objective is to create awareness throughout Namibia of RETs, addressing the particular needs of the stakeholders.

3 **Component 4: Financial barriers:** the primary objective of this component is to reduce/overcome the financial barriers to the supply, installation, purchase and maintenance of RETs including reduction of the price and ready availability of finance for the purchase and maintenance of systems.

4 **Component 5: Technical barrier removal/reduction:** the main objective of the reduction of technological barriers is to facilitate, support and strengthen the introduction of the Renewable Energy and Energy Efficiency Institute in Namibia, which will provide detailed technical information and develop and apply appropriate norms, standards and codes of practice as required by the RET industry and their market.

5 **Component 6: Demonstrations and pilots:** the objectives of the demonstration component of this Project are two fold: to test the transformed market for RESs and refine project activities to successfully complete the market transformation; and tangibly/visibly raising the profile of RETs through affirming demonstrations of their appropriate applications throughout Namibia.

As part of its efforts to decrease technical barriers, NAMREP needs to engage in the development and implementation of viable Standards and Code of Practice for Solar Energy Technologies in Namibia.

2. OBJECTIVE OF THE CONSULTANCY

The objective of the consultancy is to compile a list of recommended products meeting a set of criteria and to develop/adapt a Code of Practice for the three Renewable Energy technologies, viz., Solar Home Systems, Solar Water Heaters and Solar Water Pumps, in Namibia.

3. SCOPE OF THE CONSULTANCY

The consultants shall:

- Prepare criteria for evaluating compatibility of current Namibian SET products for Namibian conditions.
- Compile list of recommended products for Solar Home Systems, Solar Water Heaters and Solar Water Pumps.
- Review the existing code of practice as well as best practices for the three solar energy technologies, viz., Solar Home Systems, Solar Water Heater and Solar Water Pump, from at least three countries with conditions similar to those of Namibia, including those from South Africa where and if available.

- Develop/adopt a practical installation guide (Code of practice) for the three SET's.
- Liaise with RE suppliers, technicians and any other stake-holders to find the best ways of maintaining and updating recommended products listings in the solar industry in Namibia. Prepare a guideline for upholding these SET product listings and enforcing adherence thereto.
- Present findings to a supplier stake-holders workshop of about 10-40 participants.
- Prepare a final report that shall include stake-holders suggestions.

.

4. REQUREMENTS OF THE TEAM:

The team leader shall be a renewable energy expert with tertiary qualification as well as technical and economic understanding of Solar Energy Systems. Core members that make up the study team should have adequate engineering/technical background and experience in renewable energy.

The consultant should provide detailed plan, including the methodology of how the consultancy will be conducted.

The consultant shall provide CVs with the bid document and detailed budget in a **separate envelope.**

(i) IMPLEMENTATION ARRANGEMENTS

The consultant will be commissioned by NAMREP in consultation with the Ministry of Mines and Energy. The final report (10 hardcopies and a soft copy) should be submitted not later than 31 May, 2006.

NAMREP will cover the cost of the venue and full expenses for the workshop participants. All other arrangements and expenses will be done by the consultants in consultation with the client.

6. SUBMISSION PROCEDURE

Interested organizations and/or individuals should deliver/send their submissions to:

National Project Director
UNDP/GEF/MME Namibia Renewable Energy Programme - NAMREP
Ministry of Mines and Energy
Attention: Veiko Nangolo
1st Floor Ministry of Mines and Energy Building
Private Bag 13297
1 Aviation Road
Windhoek

Or e-mail to: **vnangolo@mme.gov.na** or **weah_veiko@hotmail.com**

Inquiries: Veiko Nangolo: Tel: 061 – 2848170 or Cell: 0811 244 172

DEADLINE FOR SUBMISSIONS: 28 November 2005 @ 17h00